The Silurian Formations of Northern Indiana

INDIANA DEPARTMENT OF CONSERVATION
GEOLOGICAL SURVEY BULLETIN 32

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The Silurian Formations of Northern Indiana

By ARTHUR P. PINSAK *and* ROBERT H. SHAVER

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ILLUSTRATIONS

[Plates are in pocket.]

TABLES

THE SILURIAN FORMATIONS OF NORTHERN INDIANA

By Arthur P. Pinsak[1] and Robert H. Shaver

ABSTRACT

The Silurian rocks in northern Indiana include, in ascending order, the Brassfield Limestone (lower Silurian), the Salamonie Dolomite, the Louisville Limestone, and the Wabash Formation, all of the Niagaran Series (middle Silurian), and the Salina Formation (middle? and upper Silurian). Some of these names are new or newly applied in this area. The oldest exposed Silurian rocks (Brassfield) are found in the southeastern part of the area, and they are highest on the major positive structural feature of the area, which is the northwest extension of the Cincinnati Arch. Generally younger rocks are found exposed northwestward, but the Salina Formation interrupts this pattern and is exposed in two areas centered in Howard and Cass Counties and in Jasper County.

A disconformity appears to separate Silurian from older rocks, and the upper part of the Richmond Group (upper Ordovician) possibly is absent from parts of northwestern Indiana. The Ordovician Silurian boundary can be identified readily by conodont faunas, and no variation of the regular order of succession of named lower Silurian units has been observed. Thus there is no evidence favoring the classic idea of a barrier between northern and southern parts of the State.

The Brassfield Limestone is 6 to 100 feet thick and consists of mostly noncherty partly glauconitic carbonate rocks. The formation corresponds only to the lower part of what commonly has been called the Brassfield in subsurface studies. As thus restricted, the Brassfield in its different areas is equivalent to part of the Edgewood Limestone and the lower part of the Kankakee Dolomite of northeastern Illinois and the lower part of what has been called the Cataract Formation in northern Indiana and southern Michigan.

The Salamonie Dolomite (new name; lower Niagaran) is 95 to 275 feet thick, partly argillaceous and cherty in its lower part, and pure vuggy dolomite in its upper part. This formation is equivalent approximately (1) in its lower and middle parts to the Osgood Formation and the Laurel Limestone of southern Indiana, (2) to the Dayton

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Limestone through the Cedarville Dolomite of Preble County, Ohio, (3) to most of the Kankakee and Joliet Dolomites of northeastern Illinois, and (4) to some of the so-called Brown Niagaran and White Niagaran rocks and much of the undifferentiated Niagaran rocks of the Michigan Basin.

The Waldron Formation (new surname), about 15 feet thick, consists of nodular argillaceous dolomite; the Louisville Limestone, about 60 feet thick, consists variably of argillaceous and fossil fragmental rocks. These formations, of middle Niagaran age, are absent from the area that generally corresponds to the northern two tiers of Indiana counties and where the combined thickness of the underlying Brassfield and Salamonie rocks is greater than 300 feet. In this area the Salina Formation overlies the Salamonie Dolomite. The Waldron and the Louisville correspond to the Waukesha Limestone and possibly to the lower part of the Racine Dolomite of northeastern Illinois.

The Wabash Formation (new name; upper Niagaran) is about 150 to more than 200 feet thick and consists of reef-bearing argillaceous and cherty carbonate rocks. It includes the Mississinewa Shale and Liston Creek Limestone Members (new ranks) in their type areas in north- central Indiana. The term Huntington Lithofacies (no status in systematic nomenclature) is given to reef, biohermal, and bank lithologies, and the name Fort Wayne Bank is applied to the basin-fringing accumulation of vuggy biohermal and biostromal dolomites that extend from near Fort Wayne to Lake Michigan. The Wabash Formation terminates northward in its bank phase against the Salina Formation, generally along the southern part of the northern two tiers of Indiana counties. It corresponds mostly to the Racine Dolomite of northeastern Illinois and to the Guelph Dolomite of areas north and east of Indiana.

The Salina Formation (Niagaran? and lower Cayugan) consists variably of laminated, shaly, cherty, or pure carbonate rocks. This formation is 500 feet thick in northeastern Indiana but wedges out southwestward in two fingerlike projections that apparently are controlled structurally. These projections lie in the Logansport Sag and in the Jasper Sag (new name), where Salina and Wabash rocks are juxtaposed. The Salina includes the Kokomo and Kenneth Limestone Members (new ranks) and other, unassigned rocks. The Salina Formation in Indiana corresponds mostly to the A unit and partly to higher units of that formation as understood in Michigan. Possibly the Salina in its areas of great thickness in Indiana and in Michigan has partial age equivalence with Wabash rocks and rocks as old as the Waldron, but not necessarily in areas having close proximity.

On the north flank of the Cincinnati Arch, Silurian rock units are overlain disconformably by sandy dolomites and higher carbonate and gypsiferous rocks in a southwestward-thinning wedge of rocks called the Detroit River Group (middle Devonian) in Michigan. Somewhat younger middle Devonian rocks, correlating with part of the Traverse Group of Michigan, overlap onto Silurian rocks in part of the study area.

During early and early-middle Silurian time, most of central Indiana was a broad shelflike area having shallow water and receiving skeletal and other mostly carbonate sediments. The northernmost part of the State was a marginal part of a subsiding basin and received similar materials. Structurally controlled embayments from the basin encroached into the shelf area. During late middle and late Silurian time, probably coincident in part with reef and fringing bank growth in the shelf area, the embayments became better defined and served as inlets from the south into the thenrestricted basin, where the Salina was deposited. After a period of erosion and (or) nondeposition, middle Devonian sedimentation reflected further restriction or closing of the inlets, as carbonate rocks and evaporites were deposited in the south flank area of the basin.

INTRODUCTION

IN RETROSPECT

Rocks of the Silurian System are at the bedrock surface in the triangular area extending across northern Indiana from Richmond to Fort Wayne to Chicago (fig. 1). These rocks range from 400 to 900 feet in thickness where they are overlain by rocks of the Devonian System along the flanks of the Michigan and Illinois Basins.

Over most of the triangular area, these rocks are hidden by glacial drift, and exposures are isolated in major stream valleys and in a few upland quarries. Silurian rocks were noted in the earliest geologic account of the State by D. D. Owen more than 120 years ago, and, seeming to have qualities attractive to geologists, they are the subject of many now-classic paleontologic, stratigraphic, and structural reports, among them, accounts by S. A. Miller, James Hall, S. S. Gorby, E. M. Kindle, August F. Foerste, E. R. Cumings, and R. R. Shrock.

These persons and others used outcrop data to interpret the regional strati graphic and structural relationships, but correlation of the Silurian rocks has remained as one of the more basic geologic problems in the State. It is true that hundreds of deep wells drilled

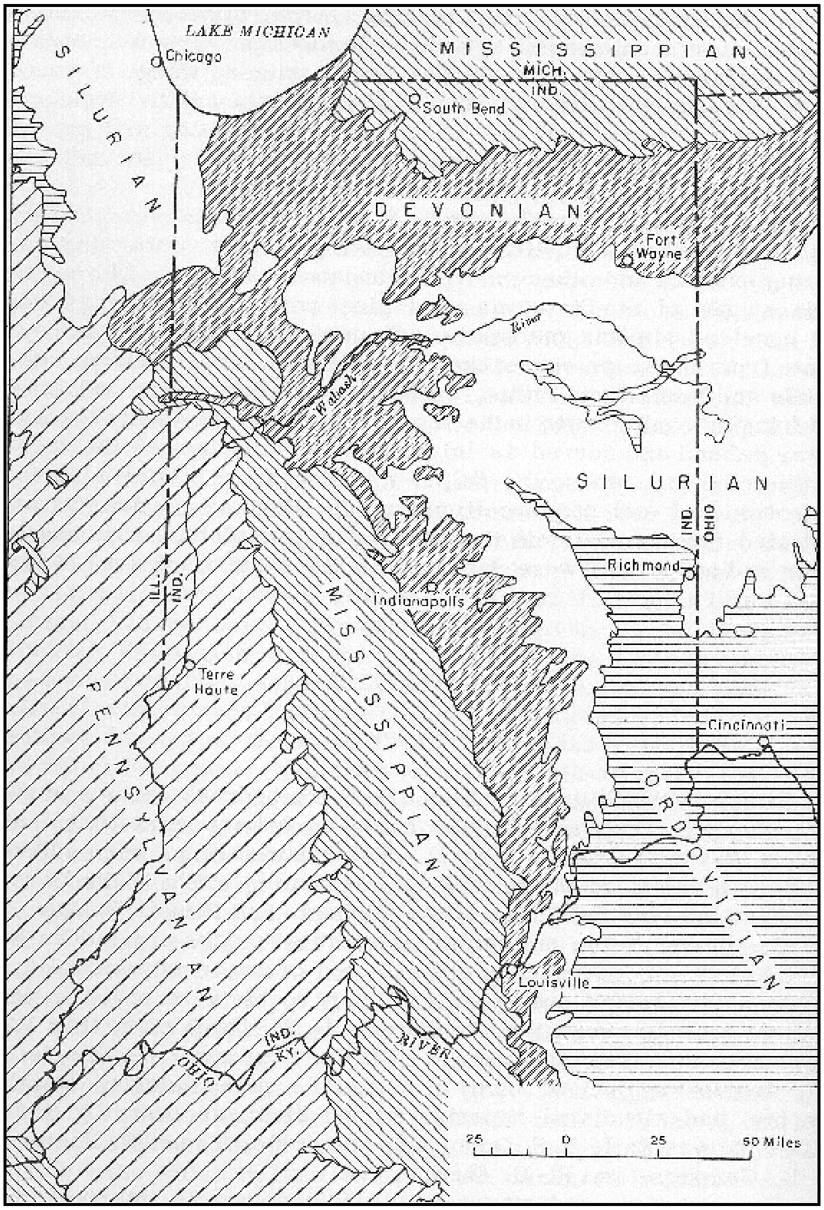

Figure 1. - -Generalized geologic map of Indiana and parts of adjoining States. Part of geology modified from Stose, 1932, Patton, 1956, and Illinois State Geological Survey, 1961.

in the old fields in the Trenton Limestone penetrated the Silurian but nearly all the records read, approximately, "Lime, Niagara, 235 feet." Thus, an example of the kind of question that has had a doubtful answer until the last dozen years is: Do the Silurian rocks that thicken northward from Richmond correlate with units in the upper part of the Niagaran Series that are exposed in the Wabash Valley or do these rocks correlate with lowest Niagaran rocks that are found only in wells in the Wabash Valley? A question that is not yet fully answered is: What part of these rocks correspond to the rocks that are labelled "Niagaran, undifferentiated" in the Michigan Basin?

Silurian rocks of northern Indiana have evoked fresh interest during recent years because of renewed drilling activity throughout the south edge of the Michigan Basin since the discovery of significant quantities of oil in southern Michigan in 1956. Many excellent Silurian rock cores have been cut as a result of interest in underground storage of gas and liquid hydrocarbons; large quarries continue to be deepened; and one contains a continuous exposure of more than 150 feet of Silurian rocks. All this new information certainly warrants reexamination of these rocks, a reexamination that has been in progress at the Indiana Geological Survey and other organizations, actually, for many years through stratigraphic studies from well data by Esarey and Bieberman (1948), through the applied studies of the Industrial Minerals and Geochemistry Sections, through preparation for the Tenth Indiana Geologic Field Conference (Shaver and others, 1961), and through other investigations too numerous to mention here. Studies for the last-named report have been continued, and they form the basis for this report. Investigations in adjacent States have produced concepts of the regional framework with which the present study is in considerable agreement. Among them are reports by Lowenstam (1948, 1949, 1950), Cohee (1948), Landes (1945), Alling and Briggs (1961), and Ells (1958).

PURPOSE OF STUDY.

The primary objective of this study is to describe the Silurian rocks of that part of Indiana lying north of Indianapolis (fig. 2). This objective has resulted in our recognition of several Silurian rock units of southern Indiana in the northern Indiana subsurface and in our correlation of Silurian and Devonian rock units with those in the Michigan Basin. These correlations, together with lithologic data, permit reconstruction of the regional structural and sedimentary framework, and a final objective is partial revision of the stratigraphic nomenclature to fit our present understanding of the rocks.

METHODS, SCOPE, AND ACKNOWLEDGMENTS

This report is based largely upon microscopic examination of materials on file in the sample library of the Indiana Geological Survey, which contains more than 260 sets of cuttings from wells that penetrate the entire Silurian System of rocks in the area of study. In addition, more than 35 cores of Silurian rocks were studied, many crossing the Ordovician boundary. Outcrops in the drainage basin of the upper Wabash River also were examined.

Electric logs are available for some wells but were of little help for recognizing the separate rock units, because in the area of study all units consist primarily of dolomite. Insoluble residues were prepared for the isolation of conodont faunas in parts of nine cores that cross the Ordovician- Silurian boundary. Paleontologic evidence is offered in support of stratigraphic and paleogeographic interpretations.

Thanks are due Heinz A. Lowenstam, David Swann, and H. B. Willman for their criticism of parts of the manuscript. Carl B. Rexroad's and Michael C. Mound's information on conodonts and foraminifers from cores in northern Indiana was useful. Special thanks are offered to Arthur J. Boucot, who identified many Silurian brachiopod faunas from Indiana and advised on the correspondence of American and British terminology.

During the late stages of preparation of this report a microfilm copy of a Ph.D. thesis, "Silurian of Northern Indiana," by John B. Sangree (1960) became available. Sangree drew stratigraphic concepts that are partly similar to those in the present report, although his recommendations for revision of nomenclature are less conservative. Sangree's facies maps provide more exact sedimentary analyses than are offered here.

REGIONAL STRUCTURE

Present regional structure in the area of study consists of three major elements (fig. 2). (See also pl. 2D.) (1) The broad crestal feature that extends from east-central Indiana northwestward to Lake County is referred to as the Cincinnati Arch[2] . It is con-

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[2]Pirtle (1932, p. 147, 149) loosely defined a Kankakee Arch, a name having even earlier usage (Morris -Kankakee Anticline of Cady, 1920, p. 88, 133), as a southeastward - trending structure crossing from northeastern Illinois into northwestern Indiana at the southwest corner of the Michigan Basin. He stated that it connected the Wisconsin and Cincinnati Arches and assumed some early Paleozoic or

sidered to merge with the Jessamine and Nashville Domes of Kentucky and Tennessee toward the southeast and south and with the Wisconsin Arch toward the northwest. It constitutes a part of the Indiana-Ohio Platform of Green (1957, p. 634). The crestal area of the Cincinnati Arch is broad and platformlike, having breadths of a few scores of miles. In this area the dip is low or indeterminate, whereas it is 35 feet or more per mile on the flanks of the arch. In the crestal area, given stratigraphic horizons decrease in altitude northwestward by a few hundred feet from east-central Indiana to Cass County in north-central Indiana; northwest of there the crestal area is interrupted by two southwestward -trending depressions. These depressions have less than 100 feet of relief along most of their extent (pl. 2D).

The southern saddle, which crosses the Cincinnati Arch from Tippecanoe County to Fulton County, is called the Logansport Sag (Cumings and Shrock, 1928b, p. 588); the northern depression, in Newton, Jasper, and Starke Counties, is here named the Jasper Sag. Green's name, Francesville Arch, is here modified to "Francesville Dome" and applied in the domal sense of Eardley(1951, p. 5) to the positive anomaly between the two saddles in White, Jasper, Pulaski, Cass, and Fulton Counties. (See footnote 2, p. 12.)

(2 and 3) North and southwest of the Cincinnati Arch are the flanks of two large structural depressions, the Michigan and Illinois Basins. Dip from the flank of the arch into these basins is approximately 35 feet per mile. The dip of Silurian units varies somewhat with stratigraphic level, especially in northern Indiana, where dip is greater for deeper horizons.

The gross structural features have influenced the outcrop pattern of Silurian formations, whose configuration has been a subject of disagreement for many years. When one considers the partial

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Precambrian deformation. Green (1957, p. 633) pointed out the difficulty in connecting the two arches in the way that had been proposed and recommended dropping the term Kankakee Arch. The "Tectonic Map of the United States" (Cohee, 1962) shows "Kankakee Arch" printed over a small positive area in northwestern Indiana near what Green (1957, p. 634) had called the Francesville Arch. What the Tectonic Map Committee intended "Kankakee Arch" to apply to exactly is not clear, and by means of a sufficiently large contour interval on the Trenton Limestone the city of Kankakee, Ill. , appears at the edge of an area extending through the Francesville Arch of Green and to the Ordovician outcrop in east- central Indiana without structural interruption. Rather than defining a possible third or fourth Kankakee Arch or resurrecting the Wabash Arch of Gorby (1886), we are using the name Cincinnati Arch here with regional extent throughout Indiana.

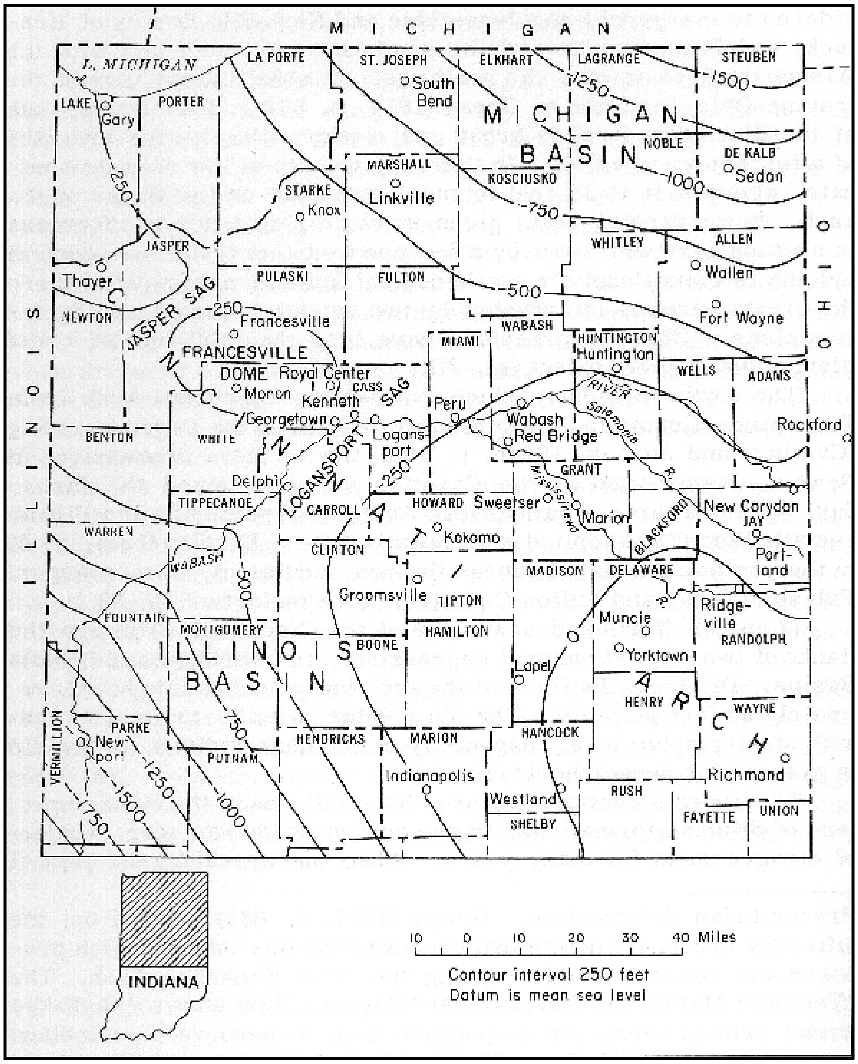

Figure 2. - - Map of northern Indiana showing structure on top of the Trenton Limestone and named structural features and localities. Structure from Dawson, 1952.

development of some of these features during Silurian time and their relation to the sedimentary succession, successively younger Silurian formations should be found not only down the flanks of the Cincinnati Arch but also northwestward along the crestal area.

STRATIGRAPHY

ORDOVICIAN-SILURIAN BOUNDARY

The Ordovician- Silurian boundary is marked by an unconformity, but it commonly is difficult to recognize and has not been applied consistently in northern Indiana wells. Apparently, the Brassfield Limestone (lower Silurian) of the northern Indiana subsurface has not been well understood; formal terminology has not been applied definitively to other lower and middle Silurian rock units, or it has been applied without consideration of the great amount of section lying below the exposures of reef -bearing rocks; and it is not known whether the unconformity is essentially one of nondeposition or one of erosion. To state these problems more simply: Are Ordovician and Silurian rocks immediately below and above the systemic contact time- transgressive, and do they fall readily into the same or different rock units on opposite sides of the State?

In the eastern part of the study area, the most common lithologies in uppermost Ordovician rocks are light- to dark-colored mottled fine- to coarse-grained fossil-fragmental limestone and dolomitic limestone that is interbedded with or has intercalations of gray- green calcareous shale and green fine-grained argillaceous dolomite. Glauconite, pyrite, and chert are present in minor amounts. In places beds of brassy-colored limestone and dolomite commonly have been misidentified as the Brassfield Limestone. All the uppermost Ordovician rocks generally are assigned to the Richmond Group of the Cincinnatian Series. (See Appendix, sections 13 and 16.)

Cincinnatian rocks thin as much as 400 feet from east to west across the State. The relative amount of silt and clay increases in the same direction, and the term Maquoketa Shale has been applied in western Indiana (Gutstadt, 1958) to the dark fine-grained silty and argillaceous carbonate rocks that occur uppermost in the Ordovician.

Lowermost Silurian rocks generally are more uniform and consist of gray and tan granular carbonate rocks that are in part argillaceous or shaly, cherty, and glauconitic. These characteristically lie just below a prominent cherty and glauconitic unit that contains crinoidal and, other silicified fossil fragments. Coarsegrained multicolored crinoidal limestone characteristic of the Brassfield Limestone on outcrop is mostly absent from subsurface sections.

These generalities seem to be applied easily enough to the systemic contact, but some wells penetrate carbonate rock on carbonate rock across the boundary; red to brown ferruginous rocks near the contact as seen in some wells in far northern Indiana may be either Ordovician or Silurian in age at their different points of observation. Such rocks normally are assigned a Silurian age (Appendix, sections 4 and 6), but some ferruginous rocks in Michigan, Wisconsin, and Illinois are late Ordovician in age (Cohee, 1948; Willman, 1962, p. 62). Thus supporting criteria for distinguishing the Ordovician- Silurian boundary are developed here.

The boundary is fixed within a few feet by means of conodonts that are found in most of the 75 insoluble residues of cores from nine wells in the area between Richmond and Chicago (table 1). The Silurian fauna (table 2) is sparse and is dominated by simple cones, whereas the Ordovician conodont fauna (table 3) is abundant and consists of many complex well-known Cincinnatian forms in addition to simple cones. The faunal determination allows lithologic characterization of the residues by age (table 4).

Some older macropaleontologic evidence suggests that the Maquoketa Shale of Iowa has equivalents in the Richmond Group, but later published work on the late Ordovician conodonts from either side of the Illinois Basin, including the species identifications here, does not necessarily support any conclusion that uppermost Ordovician rocks are approximately the same age across the northern Indiana subsurface. (See Sweet and others, 1959; Glenister, 1957; and Branson, Mehl, and Branson, 1951, for discussions and citations of pertinent literature.)

Some Ordovician conodont taxa (table 3) that offer dissenting evidence, considering earlier observations, are *Ambalodus, Amorphognathus, Dichognathus, Oulodis,* and *Sagittodentatus.* They have not been known previously from rocks higher than the lowest member of the Maquoketa Shale in Iowa, that is, from rocks considered to be as old as and older than the Arnheim Formation (pre-Richmond of Indiana). Other taxa that have not been known previously from the youngest exposed Richmond rocks are *Belodina, Cordylodus, Cyrtoniodus, Phragmodus, Pteroconus,* and *Zygognathis defomis.* Their occurrence near the top of Ordovician rocks in the core from Wayne County (table 3), taken from proximity of outcrop of youngest Richmond rocks, suggests, however, that the youngest Richmond conodont fauna from the Richmond type area is imperfectly known.

The known Silurian conodont fauna (table 2) as yet consists of too few taxa to be considered closely comparable to the fauna from the type Brassfield Limestone of Kentucky (Branson and Branson, 1947). Furthermore, the genera of arenaceous foraminifers recovered from the lowest Silurian rocks in some wells (Appendix, section 12) are considered by some persons to be most characteristic of lower Niagaran rocks (Lowenstam, 1949, p. 21), that is, of rocks considered to be younger than type Brassfield rocks.

To understand late Ordovician and early Silurian events in northern Indiana, this faunal evidence should be considered together with the westward- thinning Cincinnatian section, a Silurian section that thickens northeastward and southwestward from the area of study, and the occurrence of reworked Ordovician detritus in basal Silurian rocks (table 4), including Ordovician conodonts as high as 30 feet above the systemic contact in one core. This evidence permits the assumption of some differential movement and erosion prior to and during Silurian deposition in northern Indiana; lowermost Silurian rocks may not be exactly the same age everywhere in northern Indiana. Fixing of the Ordovician- Silurian boundary by faunal means, however, in conjunction with the physical correlations made here, refutes the concept, prevalent in classic literature, of any Silurian prototype of the Cincinnati Arch that could cause a northeastward wedging out of all the lowermost Silurian rock units against the postulated arch or barrier in northern Indiana. On the contrary, the same objectively named lower Silurian rock units can be recognized nearly everywhere at expectable heights above the systemic boundary in the area of study.

BRASSFIELD LIMESTONE

The Brassfield Limestone (Foerste, 1906) has been poorly defined in the subsurface, where chert and glauconite generally have been considered to be definitive, but this concept is rejected here. The distinctive varicolored coarse-grained thick-bedded limestone that overlies Cincinnatian rocks in southeastern Indiana is rarely found in the subsurface beyond the first tier of counties north and west of the area of exposure (Esarey and Bieberman, 1948, p. 25). A core (Appendix, section 17) that was cut north of Richmond in Wayne County illustrates that compromise is needed between field and subsurface practices. Here 8 feet of the characteristically developed coarse-grained Brassfield Limestone, somewhat brecciated and having shaly intercalations, lies on light-colored Cincinnatian limestone from which it has been distinguished by means of conodont identifications. This rock underlies 12 feet of gray-tan mostly fine-grained noncherty dolomitic limestone that in turn underlies cherty dolomitic limestone. Only the cherty limestone commonly has been called the Brassfield in the subsurface, as for example by Esarey and Bieberman (1948), Freeman (1951, p. 8, 9), Shaver and others (1961), and Shaver (1962) in part, whereas only the lower mostly noncherty limestone and dolomite are referred here to that formation in Indiana. The overlying cherty rocks are here assigned to the Salamonie Dolomite (new name) in its northern Indiana area of occurrence.

Table 1.-Cored wells of northern Indiana from which insoluble residues and conodonts were obtained

No.	County	Well	Depth in feet		
			Silurian rocks sampled	Boundary	Ordovician rocks sampled
1	Lake	Texas Eastern Transmission Corp. Buckeye Pipeline Co. Terminal No. 1 sec. 3, T. 35 N., R. 9 W., alt 629 .	573-611	below 610	—
2	Cass	Northern Indiana Public Service Co. Gale M. and Glada Skinner No. 1, sec. 10, T. 28 N., R. 1 W., alt 721 .	—	583½	584-587
3	Grant	Indiana Geological Survey drill hole 25, sec. 2, T. 24 N. , R. 6 E., alt 814 .	293-308	308½	309-324
4	Jay	Indiana Geological Survey drill hole 44, sec. 30, T. 23 N., R. 14 E., alt 835 .	39-102	102 ± 5	102-174
5	Tipton	Indiana Geological Survey drill hole 41, sec. 17, T. 22 N., R. 3 E., alt 874.	477-534	534 ± 1	534-555
6	Marion	Indiana Geological Survey drill hole 14, sec. 20, T. 17 N., R. 4 E., alt 720 .	253-284	286	286-296
7	Marion	Indiana Geological Survey drill hole 35, sec. 18, T. 16 N., R. 4 E., alt 735 .	310-347	347	348-356
8	Wayne	Indiana Geological Survey drill hole 57, sec. 12, T. 14 N., R. 1 W. , alt 1, 028.	20-421	42½	42½ -50
9	Owen	Schwart. et al. , Everhart No. 1, sec. 21, T. 9 N., R. 5 W., alt 670.	2,065-2,123	2,123	2,124-2,259

Table 2.-*Species of conodonts from lowermost Silurian rocks in cored wells of northern Indiana*
[See table 1 for names and locations of wells.]

Species	Formation: Salamonie Dolomite[1]	Formation: Brassfield Limestone	Formation: Undetermined
Acodus curvatus	X	X	
A. unicostatus	X	X	
Distamodus kentuckyensis	?	X	
Ligonodina kentuckyensis ?	X		
Lonchodus spp	X	?	
Ozarkodina. typica		X	
Panderodus acostatus	X	X	
P. bicostatus	X	X	
P. cf. P. recurvatus			X
P. Unicostatus	X	X	
P. sp	X		
Prioniodina cf. P, ? deflectus		X	
Spathognathodus primus		X	
S. ? sp		X	
Trichonodella spp	X	X	

[1]New name; see page 24.

Table *3.-Some species of conodonts from uppermost Ordovician rocks in cored walls of northern Indiana*

[See table 1 for names and locations of wells.]

Species	Wells selected for identification						
	1. Lake County, below 610 ft [1]	2. Cass County , 584-587 ft	4. Jay County, 104-132 ft	4. Jay County, 160 - 173 ft	5. Tipton County, 534-547 ft	6. Marion County, 286-296 ft	8. Wayne County, 44-50 ft
Ambalodus triangularis ?						X	
Amorphognathus ordovicia?-					X		
Aphelognathus grandis			X	X			X
Belodina, compressa-		X	X		X	X	X
B. cf. B. dispansa			X				X
Coelocerodontus trigonius					X	X	X
Cordylodus delicatus-	X		X	X	X	X	X
C. excavatus			X		X		X
Cyrtoniodus complicatus		X	X	X	X	X	X
Dichognathus brevis					X	X	
D. typica					X	X	
DrO~panodus honnocurvatus			X	X	X	X	X
D. suberectus			X	X	X	X	
Eoligonodina richmondensis			X	X			
E. robusta			X	X	X		
Lonchodus sp			X	X	X	X	X
Micrococelodus sp			X		X		X
Oistodus inclinatus	X	X	X	X	X	X	X
Oulodis mediocris			X				
Ozarkodina concinna			X	X	X	X	X
0. robusta					X	X	
0. sp					X		
Panderodus angularis			X				
P. compressus					X	X	X
P. gracilis		X	X	X	X	X	X
P. intermedius				X	X		X
P. panderi-					X		
P. robustus				X			

Table 3.-Some species of conodonts from uppermost Ordovician rocks in cored wells of northern Indiana-Continued

Species	Wells selected for identification						
	1. Lake County, below 610 ft[1]	2. Cass County, 584-587 ft	4. Jay county, 104-132 ft	4. Jay County, 160-173 ft	5. Tipton County, 534-547 ft	6. Marion County, 286-296 ft	8. Wayne County, 44-50 ft
Phragmodus undat-		X	X	X	X	X	X
Prioniodina oregonia			X	X	X		X
Pteroconus gracilis						X	
P. t.rtus			X	X	X		X
Rhipidognathus eurvata			X	X			X
R. paucidentata			X				
R. syrnmetrica			X				
R.sp			X				
Sagittodentatus cf. S. dentatus						X	
Trichonodella tenuis			X	X	X	X	
T. undulata			X		X		X
T. p					X	X	X
Zygognathus deformis			X	X	X		X
Z. pyramidalis					X	X	
Z. plebia			X				

'The lowest sample, 610-611 ft, examined in the Lake County core apparently has reworked Ordovician conodonts in rocks also yielding Silurian conodoms. Although the sampled rock is Silurian in age, we have listed the Ordovician conodonts here.

Table 4.-*Characteristics of insoluble residues of rocks from near the 0rdovician-Silurian boundary in cored wells of northern Indiana*

[More diagnostic criteria are indicated by capitalization. See table 1 for names and locations of wells.]

Constituent	Residues from Silurian rocks	Residues from Ordovician rocks
Clay and silt	Mostly moderate or slight, tending to be greater in the lowest rocks.	COMMONLY HEAVY even in granular carbonate rocks.
Glauconite	Present in about half the residues of noncherty rocks; IN ALL, RESIDUES OF CHERTY ROCKS.	Present in about half the residues; not consistent from well to well.
Siliceous fossil and other fragments	DOMINANT IN MANY RESIDUES.	Rare to common in some residues
Clayey and shiny fossil molds and casts, especially bryozoans and mollusks	PRESENT IN BASAL RESIDUES AS REWORKED ORDOVICIAN MATERIAL IN PART.	COMMON TO ABUNDANT IN MOST RESIDUES.
Conodonts	Rare to common in many residues; SIMPLE CONES DOMINANT.	COMMON TO ABUNDANT IN MOST RESIDUES; COMPLEX CONES AND BARS DOMINANT.
Arenaceous Foraminifera	RARE TO COMMON IN SOME RESIDUES.	NONE OBSERVED.
Iron oxide and hydroxide	Commonly heavy in acid solutions of lowermost noncherty rocks.	Heavy in some solutions.
Pyrite	Common to abundant in many residues.	Common to abundant in many residues.
Chert	None in residues unless sample contained macroscopic chert; no detrital chert.	None in residues unless sample contained macroscopic chert; no detrital chert.
Other constituents, mostly minor	Siliceous oolites, quartz crystals, dolocasts, sand grains, scolecodonts, chitinozoans, ostracods, sponge spicules.	SIX-RAYED SPONGE SPICULES, sand grains, quartz crystals, dolocasts, scolecodonts, chitinozoans.

Description and distribution- The Brassfield Limestone of northern Indiana consists of gray-tan to brown fine-grained dolomitic limestone and dolomite and medium-grained fossil-fragmental limestone; thin green shale beds, light-blue to white chalky-textured chert, pelletoid glauconite, color mottling and banding, and carbonaceous laminae are common (Appendix, section 1). Average thickness for much of the area is 12 feet, but in the northeast corner of Indiana the Brassfield equivalent, part of the Cataract Formation of Michigan (Cohee, 1948), is as much as 200 feet thick (Appendix, section 4).

Lithologically, lower and upper contacts of the Brassfield appear to be transitional in many sections. Although the lower contact with Ordovician rocks has been described as disconformable, it is difficult to observe where it lies within a carbonate rock sequence. Nearly all insoluble residues yield diagnostic fossils, however, and also show reworked Ordovician material in basal Silurian deposits;

furthermore, highly shaly and silty rocks within the critical interval probably should be assigned to the Ordovician. The upper boundary truly may be transitional in most areas, although brecciation is seen in some cores. For greatest consistency this contact should be placed below the prominently cherty glauconitic rocks, not present everywhere, of the overlying section. Chert, however, gradually becomes less abundant downward in wells, accompanied by a darkening in color of the limestone or dolomite and an increase in shaly fraction, so that the upper contact commonly must be placed arbitrarily. Lowermost Silurian rocks everywhere in the study area are here considered to be a part of the Brassfield.

Correlation.--The Brassfield Limestone of southern Indiana and Kentucky outcrop long has been assigned to the Albion Series and by paleontologic means has been correlated with the Sexton Creek Limestone in the upper part of the Alexandrian Series of western Illinois outcrop. The critical fossils have not been seen in northern Indiana, so that assignment of the subsurface Brassfield to a lower series of the Silurian System is done only on the basis of similarity of stratigraphic position. The rocks at this position in Indiana differ, however, from those of the classic eastern areas by lacking significant quantities of the quartz sand that pinches out westward as a discrete unit in western Ontario (Cohee, 1948). On the basis of stratigraphic position and lithology, the Brassfield of this report in northwestern Indiana appears to correlate more readily with middle and lower Alexandrian rocks of western and northeastern Illinois, the mostly noncherty Edgewood Limestone, for example, than it does with the overlying Sexton Creek or with the cherty Kankakee Dolomite of northeastern Illinois as described by Savage (1916, p. 306, 307; 1926, p. 517-519). The lower part of what Cohee (1948) called the “Cataract formation and equivalents” in Indiana belongs in the Brassfield of this report. Exact correlation of the Brassfield with the thicker section of Cataract rocks in Michigan is uncertain (pl. 1, section D-D'), but in most of northern Indiana the Brassfield probably is younger than the oldest Cataract rocks in Michigan.

The limited number of Brassfield conodont species (table 2) identified in this study does not compare well with the Brassfield fauna of Kentucky reported by Branson and Branson (1947). The arenaceous Foraminif era (Mound, in preparation), especially ammodiscids, seem to be an enigma. Described by Dunn (1942) from the Osgood Formation and the Joliet Dolomite, they are used in a zone of abundance to mark the base of the Joliet and the top of the Alexandrian Series in northeastern Illinois; this zone is above the lowest level at which the brachiopod *Pentamerus* occurs (Lowenstam, 1949, p. 21; Willman, 1962, p. 62). In southeastern Indiana ammodiscids, including the genus *Turritellella, are* known to be locally abundant (as many as 500 specimens per kilogram) in the exposed Brassfield Limestone (Mound, 1961). In eastern Indiana, though, they are found below the lowest occurrence of the brachiopod *Pentamerus oblongus* (as well as above it). At one northwestern Indiana locality in Newton County, however, arenaceous Foraminifera occur in abundance in a zone entirely, but immediately, above Brassfield rocks and yet well below the position that is here considered to correlate with basal Joliet rocks (Appendix, section 5). Thus the Foraminifera suggest that the Brassfield, as here identified, may be time-transgressive, or possibly these foraminifers are not consistent indicators.

Altogether, correlation of the Brassfield is tenuous, and probably the outcropping Brassfield Limestone is younger than the Brassfield in the western Indiana subsurface (fig. 3). The outcropping Brassfield does contain the brachiopod *Stricklandia* (Cumings, 1922, p. 447), which indicates a position high in the Llandovery Series of British terminology. This position is stratigraphically higher than that of outcropping Edgewood faunas in Illinois with which the subsurface Brassfield of Indiana has some equivalence. (See Berry and Boucot, in preparation, and fig. 3 herein.)

SALAMONIE DOLOMITE

Definition, description, and distribution.-The Salamonie Dolomite is named here from the exposures of dolomite in the headwaters area of the Salamonie River in the vicinity of Portland, Jay County, in east-central Indiana. The type section consists of the exposure in the Rockledge Products, Inc., quarry and of the core of Indiana Geological Survey drill hole 44 (Appendix, section 13) that penetrated to Ordovician rocks from the floor of that quarry. One principal reference section near the type area is designated as the exposure in the H and R Stone Co. quarry near Ridgeville in Randolph County (Appendix, section 15). A second principal reference section is designated as the rocks cored in the Northern Indiana Public Service Co. Carl Wyneken No. 1 well near Wallen, Allen County (Appendix, section 6). Two additional reference sections are designated as the rocks cored in (1) Indiana Geological Survey drill hole 72 in Kokomo, Howard County, and (2) Indiana Geological Survey drill hole 96 near Yorktown, Delaware County (Appendix, sections 12 and 16).

The Salamonie Dolomite comprises in northern Indiana the rocks overlying the Brassfield Limestone as recognized hereinand underlying the Waldron Formation (new surname). In most of the northern two to three tiers of Indiana counties, where the Waldron

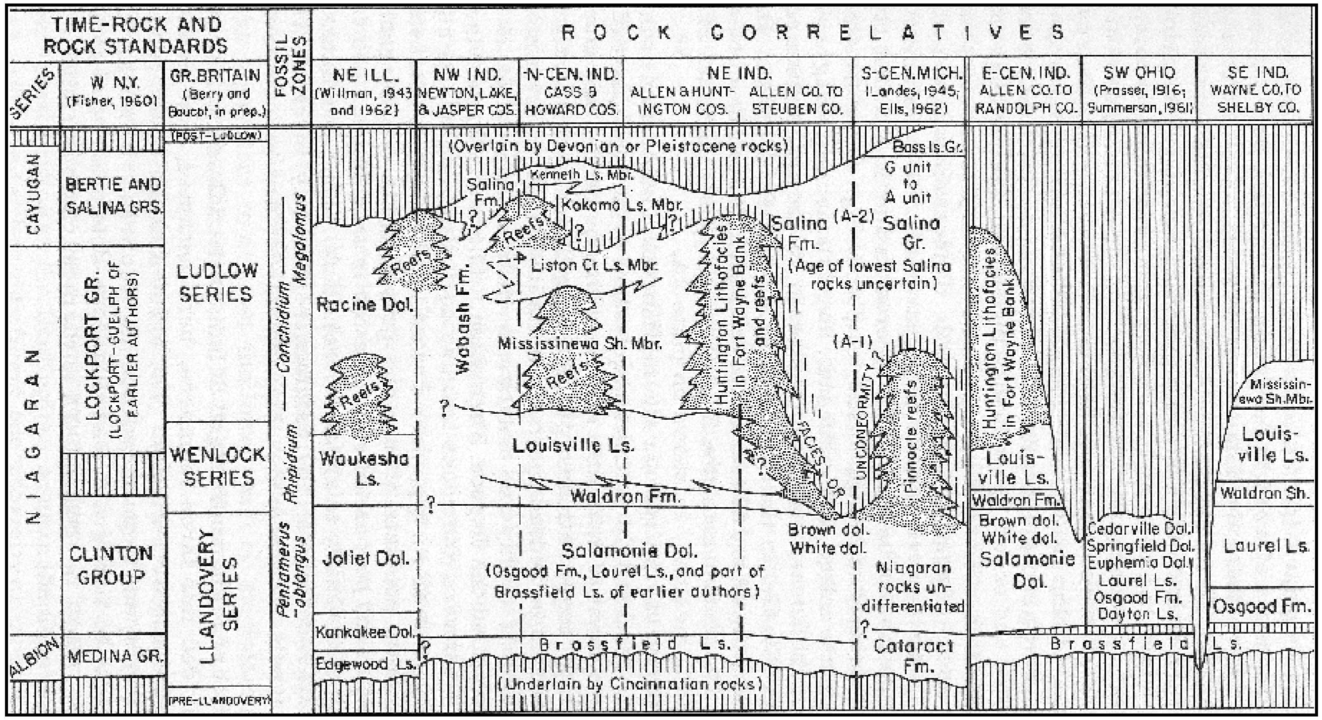

Figure 3. –Correlation of Silurian rocks of northeastern Illinois, Indiana, southern Michigan, and western Ohio. Modified from Shaver, 1962.

cannot be recognized (pl. 2A), the Salamonie is overlain by dolomitic rocks here referred to the Salina Formation.

In the area where the Salamonie is exposed at the bedrock surface in Adams, Jay, and Randolph Counties, it characteristically is light-colored medium-grained fossil-fragmental porous dolomite that frequently has been called reef or reef-detrital dolomite, although reef structures are not known certainly to be exposed at this stratigraphic level in northern Indiana. (See, however, Esarey and Bieberman, 1948, p. 36.) Saccharoidal and oolitic textures are common; chert and glauconite are observed in the basal part in most places and occur sporadically throughout the vertical extent of the formation. Crinoidal fragments are conspicuous components in many areas (Appendix, section 18). Limestone appears to be common in the western subsurface equivalents. The Salamonie at the type section has been reduced by erosion and is 135 feet thick. Two counties west of the type area, in places high on the Cincinnati Arch where the entire unit is present, the Salamonie averages about 90 feet in thickness, but it increases in thickness northward to more than 200 feet in the flanking portions of the Michigan Basin and northwestward to 180 feet near the Illinois State line in Newton County. The thickness of the Salamonie, together with that of the Brassfield Limestone, is shown on plate 2A.

Southwest of the type area, in Hancock County for example (Appendix, section 19), the rocks equivalent to the lower part of the Salamonie consist of dolomitic limestone that is banded and mottled tan and gray, dense to coarse grained, argillaceous and partly thin bedded and of interbedded green shale and limestone; chert is mostly absent. In this county and southward these rocks, 15 to 20 feet thick, are called the Osgood Formation. Above the Osgood in this area and southward the rocks that are equivalent to the upper part of the Salamonie in its type area are called the Laurel Limestone. This formation consists of tan and gray fine- to coarse-grained fossil-fragmental porous limestone; chert is uncommon. The Laurel in Hancock County is about 45 feet thick. Thus the thickness and dolomite content of the Salamonie generally increase from south to north, whereas the clay content decreases in the same direction.

In much of the northern third of Indiana the Salamonie Dolomite can be divided into three members, here unnamed, that maintain considerable lateral continuity. The lower member corresponds to the basal cherty and impure rocks in the type area. It is light-gray and tan dense to fine-grained argillaceous dolomite and dolomitic limestone. Chert is abundant and is the most characteristic aspect of the lower member.

The middle member corresponds to the upper rocks in the Salamonie type section. It is light-gray to white granular porous vuggy dolomite having secondary dolomite rhombohedrons and sparry calcite. Dolornitized fossils are common. This outstanding high-purity dolomite commonly has been referred to as reef-type dolomite in subsurface studies.

The upper member, not present in the type area, consists of gray, tan, and brown limestone and dolomite that wedge out southward in the central part of Indiana. These three members are more than 200 feet thick in the southern part of the Michigan Basin (pl. 1, section D-D').

The lower boundary of the Salamonie has been discussed in the section on the Brassfield Limestone; the upper contact with the Waldron Formation of this report (p. 29) is distinct throughout most of the area of study, because the Waldron is a distinctive shaly carbonate unit with a well-defined base. Northwest and north of the area of Waldron occurrence (pl. 2A), the upper contact of the Salamonie is difficult to recognize in places where fairly pure carbonate rocks of the Louisville Limestone or the Salina Formation overlie the Salamonie (fig. 3). Means of recognizing the Salamonie Salina boundary in far northern Indiana are discussed further on page 54.

Correlation.-The name Salamonie Dolomite here replaces the northern Indiana term Osgood-Laurel of older reports. As correlated in plate 1 the upper Salamonie rocks are not accounted for by the named southern Indiana units, although their ages may be closely similar (fig. 3). The lower cherty glauconitic carbonate rocks of the Salamonie are a facies in part at least of the Osgood Formation, which is a shaly unit in its type area of southern Indiana and in the southern part of the present area of study. Lower Salamonie rocks have been called the Brassfield in part in the northern Indiana subsurface, but they lie above the position of the most northerly Brassfield exposures in Indiana. The lower part thus corresponds also to part or all of the Kankakee Dolomite of Illinois as described by Willman (1943, p. 20o 30) and was partly included in the Cataract Formation and equivalents of Cohee (1948) in northern Indiana. Rocks equivalent to at least the lower part of the Salamonie have been called the Clinton in the Michigan Basin (Cohee, 1948; Ells, 1958, p. 34).

The middle sporadically cherty high-purity dolomitic limestone can be traced southward into the Laurel type area, and in east-central Indiana these Salamonie rocks have been confused until recent years with the type Huntington Dolomite (upper Niagaran). Their identification as the Huntington, so near the Ordovician exposures, supposed either significant unconformity or structural anomaly. The cherty New Corydon Limestone of Cumings and Shrock

(1928b, P. 588), in the New Corydon type area only, in Adams and Jay Counties, belongs in the Salamonie.

The middle unnamed member of the Salamonie corresponds in the Michigan Basin mostly to the so-called White Niagaran of some usage and to the Niagaran of Ells (1958, 1962). Cohee (1948) suggested that the white dolomite of Michigan might correlate with reef-containing formations in adjacent States, but Ells (1958, p. 35) doubted such a correlation. His doubt is confirmed here, as this white dolomite is older than the reef rocks in the barrier system that is discussed under the heading of Wabash Formation. (See also pl. 1, section D-D'.) Partly corresponding rocks in Illinois constitute the Joliet Dolomite in the sense of Willman (1943, p. 20, 26) and the St. Clair Formation of the Bainbridge Group as described by Lowenstam (1949, p. 16).

The upper member has not been traced into a named southern Indiana unit, but it corresponds in the southern part of the Michigan Basin to the “Brown Niagaran” of Ells (1958, p. 33), who placed it in the Salina Formation. This unit is similar to some Salina rocks, but its south extension beneath the Waldron (pl. 1, section D-D') suggests that exclusion from the Salina is the better practice for Indiana. A rock unit described as buff dolomite at the top of the Lockport-Guelf Group in Ontario (Evans, 1950, p. 60) possibly is equivalent to the upper number.

These proposals for correlation with rocks in the Michigan Basin contradict the correlations proposed by Ehlers and Kesling (1962, p. 12-15), who postulated a Mid-Michigan Ridge and believed that the Salamonie rocks of this report pinch out in southern Michigan and that the Salina Formation everywhere overlies upper Niagaran rocks rather than lower to lower-middle Niagaran rocks as is proposed here for northernmost Indiana (fig. 3).

The proposed stratigraphic relationships, worked out by physical data, appear to make new faunal studies opportune at this time. Characteristic coquinas of brachiopods of the type *Pentamelus oblongus* long have been noted in these rocks in Indiana and parts of adjacent Ohio (Cumings and Shrock, 1928a, p. 108, 110, 114), in rocks here referred to the middle and upper parts of the Salamonie, but their significance has been overlooked at times. These fossils suggest age equivalence to middle Clinton rocks along the Niagara Escarpment in Ontario (Bolton, 1957, p. 41) and to part of the Kankakee and Joliet Dolomites of Illinois; they also suggest general age equivalence of the Salamonie and several formations in western Ohio, for example the formations that at Lewisburg, Preble County, are called the Dayton Limestone, Osgood Formation, Laurel Limestone, and Euphemia, Springfield, and Cedarville Dolomites (Prosser, 1916; Summerson, 1961, p. 32).Arthur J. Boucot (written communication, February 22, 1962) places the *Pentamerus oblongus* fauna in correspondence to the upper part of the Llandovery Series or to the Wenlock Series, of British terminology, and in a lower position than the true *Conchidium*-bearing type Huntington Dolomite of older Indiana reports and the Guelph Dolomite of Ontario. Thus the pentamerid zonation renders untenable earlier correlations of the Salamonie rocks of east-central Indiana and western Ohio with the Huntington and the Guelf.

WALDRON FORMATION

M. N. Elrod (1883, p. 111) proposed the name Waldron Shale for rocks that crop out a short distance south of the present area of study in Shelby County and southward. He stated that "the Upper Niagara shale bed, is the calcareous clay, shale and thin strata of limestone overlying the quarry stone, and closing the Niagara period and group. The greater per cent. of the mass is carbonate of lime.... In general it is made up of thin laminae of shale, frequently erroneously called slate, with bands of limestone near bottom." And so it is throughout the area of occurrence of the Waldron in Indiana- -intermixed dolomitic limestone, or limestone, and shale- -but with a decided northward percentage increase in carbonate content. Thus the name is changed here to "Waldron Formation" for northern Indiana usage; the term Waldron Shale probably is preferable for southern Indiana.

Description- The Waldron Formation in northern Indiana consists of distinctive mottled dark-gray and tan fine-grained to sublithographic argillaceous limestone or dolomitic limestone. It commonly contains black carbonaceous partings and is more or less shaly. The carbonaceous partings are associated with a peculiar structure that can be seen in cores (Appendix, sections 6 and 14) and exposures but that can only be imagined in cuttings. The formation commonly is composed in part of smooth even-textured limestone nodules a few inches in diameter that are completely surrounded by the black carbonaceous and dolomitic limestone partings. The percentage of shale and the clay content of the Waldron increase to the southeast in the study area. The shale is in thin discrete beds alternating with limestone, but argillaceous dolomite or limestone is more characteristic.

The Waldron generally increases in thickness from south to north in the study area. Thickness ranges from a minimum of 5 feet through an average 25 to 30 feet near the northern limit to an observed maximum of 40 feet. The contact with the Salamonie Dolomite generally is picked easily in wells at the distinct bottom of rocks of shaly aspect. Particularly in the thickened northern sections in which shaly and clayey lithologies are less in evidence, upper Waldron rocks are transitional into the overlying Louisville Limestone, and the Waldron- Louisville contact could be placed at the top of any of several fine-grained to sublithographic argillaceous units that alternate with granular fossil-fragmental dolomite or limestone. Where this contact must be picked arbitrarily, it is placed here at the top of those argillaceous units that most nearly match the projected position of the top of the formation.

Vistribution.-The Waldron Formation is the most useful key marker in correlating Silurian rocks in northern Indiana, as it is sandwiched in a section of granular dolomite and limestone (pl. 1). It is absent from east-central Indiana, where it has been eroded, and from parts of the pre- Pleistocene Teays and Anderson Valleys, where the Waldron outcrop line on the bedrock surface is digitate (pls. 1 and 2A). The Waldron terminates northward along a line that is drawn below the northern two and three tiers of counties (pl. 2A). Here it is lost between rocks of the Salamonie Dolomite and the Louisville Limestone or Salina Formation. Along most parts of the line it terminates abruptly, inasmuch as even the lower boundary lacks definition and no particularly distinct zone of argillaceous limestone is apparent northward. The west end of the line is drawn somewhat arbitrarily, however, because in Newton and Benton Counties, where we do not recognize the Waldron as a formal unit, argillaceous limestone is present at the Waldron position in some wells (Appendix, section 5).

Correlation.-In its type area south of the area of this study, the Waldron Shale has been made famous by many reports, beginning with Hall (1862), on its more than 200 fossil species. Hall (1882, p. 219, 220) early favored comparison of the Waldron fauna with that of the Rochester Shale of New York, but the formation also has been correlated as high as the Lockport Group of that State (Bassler, 1915, pl. 3). By means of paleontology and outcrop stratigraphy the formation was traced into Kentucky and Tennessee at an early date. Northward, however, the Waldron has not been properly understood.

At one time a Silurian barrier was thought to have caused discontinuity of Silurian formations between southern and northern Indiana. Esarey and Bieberman (1948, p. 34, 35) showed that no barrier existed, but their correlation of the Waldron with the Mississinewa Shale is here rejected. Some of their statements on subsurface Waldron distribution and correlation refer to the Mississinewa Shale Member of the Wabash Formation of the present report. The unit identified here as the Waldron Formation of northern Indiana lies an average 60 feet below the Mississinewa. The Waldron of southern Indiana is Wenlock in age in the British standard, whereas the Mississinewa is Ludlow in age (Boucot and Berry, in preparation).

In the New York standard, a Rochester (late Clinton, pre-Guelph) age assignment for the Waldron (fig. 3) is preferred here, not because of reexamination of the fauna, but because of newer information on the stratigraphic position of younger described faunas that are mentioned in the section on the Louisville Limestone. In northwestern Indiana near the Illinois State line, the projected position of the Waldron is 200 feet above the base of the Silurian. Thus the Waldron and equivalent rocks possibly correlate with a lower part of the Waukesha Limestone of Willman (1943).

LOUISVILLE LIMESTONE

The Louisville Limestone in its type area consists of white limestone and brown argillaceous and dolomitic limestone as much as 60 feet thick (Foerste, 1897, p. 218, 232). Among its large suite of fossils the corals are especially noteworthy. The name Louisville has become a mainstay in the southeastern Indiana stratigraphic column, where the formation comprises as much as 50 feet of gray buff-weathering mostly fine-grained more or less fossiliferous dolomitic limestone exposed beneath middle Devonian limestone. Until recent years the Louisville was not recognized north of Shelby County, because it passes under glacial drift and is overlapped by Devonian rocks.

Description and distribution.-- In northern Indiana the Louisville Limestone characteristically is tan and gray fine- to medium-grained thick- to medium-bedded fossil-fragmental limestone and dolomitic limestone; regionally, the percentage of dolomite increases from south to north. Chert is common in the Louisville and seems to have greatest abundance in the Allen County area and southward (Appendix, section 6). Carbonaceous and argillaceous partings, wavy in part, also are common and are associated with fine-grained to sublithographic phases which commonly grade downward into the Waldron type of lithology, for example, in north-central Indiana (Appendix, section 14). Gray and tan mottling is associated with these argillaceous rocks. In some outcrops the chert and argillaceous partings upon weathering have produced a slabby aspect, so that at quarries near Muncie in Delaware County the formation had been misidentified until 1960 as the Liston Creek Limestone. Red iron stain on fossil fragments occurs sporadically and is most common in the southwestern part of the area of study (Appendix, section 18).

The Louisville thickens northward somewhat from 50 feet or less along its southern Indiana outcrop to an average of 60 feet in northern Indiana. The contacts with contiguous formations, however, commonly are transitional, so that thicknesses in individual wells, especially near the northern limit of the Louisville, need to be determined arbitrarily or by projection. The lower boundary has been discussed. The upper contact is readily identified where either fine-grained dolomitic siltstone, typical of the Mississinewa Shale Member of this report, or mottled sublithographic limestone, characteristic of the Louisville, is present; it is picked somewhat arbitrarily, however, where the basal Mississinewa consists of reef-flank and other fossil-fragmental rocks similar to coarse-grained fossil-fragmental phases of the Louisville. Some sections have a 30-foot transitional zone between characteristically silty Mississinewa rocks and the more granular Louisville; the lower 15 feet or more of this zone, depending upon gross aspect, is here assigned to the Louisville.

The northern limit of the Louisville Limestone is approximately the same as that shown for the Waldron Formation (pl. 1, section D-D', and pl. 2A) and for the Fort Wayne Bank, a linear accumulation of reef rocks newly recognized herein the Wabash Formation and probably in lower rocks. (See p. 40 and fig. 4.) North of this line the Louisville cannot be recognized, and its position is occupied by the Salina Formation. See Salina discussion on p. 47. Northwest of the Waldron extent line and southwest of the Fort Wayne Bank in northwestern Indiana, the Louisville is recognized, and similar rocks in the stratigraphic position of the Waldron are included in the Louisville (Appendix, section 5). The rocks in northwesternmost Indiana, however, need considerably more study. For the present they can be assigned to the Thorn Group of Lowenstam (1949, p. 18) wherever the formational relationships that are observed in the upper Wabash Valley area are not objectively recognizable. Eventually, several Illinois names may be adaptable in this area.

Correlation.-- The tracing here of the Louisville stratigraphic position to the Illinois State line supports some earlier correlations of the Louisville with the Waukesha Limestone (in the sense of Willman, 1943, p. 29) of the Thorn Group in southeastern Wisconsin and northeastern Illinois. (See also Lowenstam, 1949, p. 18, and the new name for part of the Waukesha, the Bellwood Dolomite, in Swartz and others, 1942, p. 536.) The physical evidence at least suggests partial correlation, and like the Waukesha, the Louisville in northern Indiana lies immediately below the prominent reef-bearing formations, or it is apparently associated with reefs as in Delaware County (Appendix, section 16) and along the Fort Wayne Bank. (See p. 41.) Lowenstam (1948, p. 11, 1950, p. 482), however, noted that reefs may have begun their growth in northeastern Illinois as early as late Joliet time (pre- Louisville). Northward in the Michigan Basin, the Louisville possibly has an age equivalent in part of the Salina Formation; we consider that the Louisville and Salina interface shown in section D-D' of plate 1 represents at least local disconformity (fig. 3).

In the early period of study the Louisville of southern Indiana generally was given a position as high as or higher than the Lockport-Guelph Group in the standard New York section, especially through consideration of the beds containing the brachiopod *Conchidium* and certain coral beds. The coral beds were noted in southern exposures of the Louisville and in what were considered to be equivalent rocks in northern Indiana that, however, are known to be younger than the Louisville. (See discussions in Cumings, 1922, p. 455; 1930b, p. 193; and 1941, p. 131; and Savage, 1926, p. 533.) Later faunal correlations, however, including those of Amsden (1949, p. 36), generally have placed the Louisville in a sub-Lockport position lower than the Guelph Dolomite. Furthermore, the graptolite fauna from Yorktown in Delaware County, described by Cumings and Shrock (1928a) and considered to be late Rochester or early Lockport in age (Cumings, 1930b, p. 195), is shown here to come from immediately above the Louisville and below the type exposures of the Mississinewa Shale Member of the Wabash Formation (Appendix, section 16). Arthur J. Boucot (written communication, February 22, 1962) considered that these graptolites are early Ludlow in age in British terminology and Geulph in North American terms.

In northern Indiana Louisville exposures collectively have yielded brachiopods of the genera *Pentamerus and Conchidium,* but the Louisville is above the stratigraphic position of the beds containing abundant *Pentamerus oblongus* and below the beds having abundant *Conchidium*. At least some of the species of *"Conchidium"* early noted and common in the Louisville should be assigned to *Rhipidium. Rhipidium multicostellum* has been identified by Arthur J. Boucot (written communication, May 22 and June 18, 1963) in rocks which have reef structure and which are here considered to be in the Louisville in the Rockford Stone Co. quarry, 1½ miles northwest of Rockford and just north of U. S. Highway 33, Mercer County, Ohio. Thus these *Rhipidium*-bearing beds are considered to be Wenlock in age in the British standard (fig. 3).

The *Pentamerus oblongus* beds of east-central Indiana and those in adjacent parts of western Ohio, which have been given names as high as the Cedarville Dolomite, and which have been correlated high up in the Lockport-Guelf Group of various authors, lie stratigraphically below the Louisville and accordingly must have pre-Guelph ages assigned. Similar conclusions were reached, at least implicitly, by some earlier authors.

WABASH FORMATION

Definition.--The Wabash Formation[3] is named here for the great body of rock in northern Indiana that extends southward from the northern part of the Fort Wayne Bank (p. 40) and that lies above the Louisville Limestone and below the Salina Formation where that formation is present south of the bank (pl. 1; fig. 4). Where the Salina is absent and where the Wabash Formation is not at the bedrock surface, it underlies rocks of the Devonian System. The type area is designated as the upper Wabash Valley in Carroll, Cass, Miami, Wabash, and Huntington Counties, where most of the characteristic aspects of the formation are revealed. Thus in earlier reports, rocks referred here to the Wabash Formation have been described as the Wabash flaggings, reef rock, Huntington stone, shell rock, reefs, bioherms, quaquaversal structures, part of the Niagara Group (lime), the Mississinewa Shale, the Liston Creek Limestone, part of the New Corydon Limestone, and part of the Huntington Dolomite.

The Wabash Formation has two major subdivisions that can be recognized in part of the area of study; the formations formerly called the Mississinewa Shale and the Liston Creek Limestone are here accorded member status and are assigned to the new formation (fig. 3). Reefs, bioherms, banks, and upper Niagaran thick-bedded reef-detrital limestones and dolomites of northern Indiana that collectively have been called the Huntington Dolomite are for the most part facies of the Mississinewa Shale and Liston Creek Limestone Members of the Wabash Formation. The Huntington type section, as specified by Cumings and Shrock (1928a, p. 95), was moved from the original site, and the term has been applied and misapplied to rocks in all parts of the Niagaran section in northern Indiana and part of western Ohio. We therefore propose that the term Huntington be abandoned as a formally ranked name in the North American stratigraphic system; in its place we propose the term Huntington Lithofacies to apply to any large body of reef rock and reeflike rock within the Wabash Formation. This application reflects rather faithfully the most common earlier use of the term Huntington Dolo-

[3] The term Wabash Formation has had scant earlier use for rocks of Pennsylvanian age in southwestern Indiana, which use we consider to be abandoned. Fuller and Clapp proposed the term in 1904, but it has not had significant use since 1932 (Logan) because the formation included rocks having other names. The Indiana Geological Survey assigns these rocks to the Shelburn Formation and to the McLeansboro Group (Wier and Gray, 1961; Wier, in preparation).

mite, and this suggestion is implicit in Kindle and Breger (1904, p. 408) and in Cumings and Shrock (1927, p. 77). We also follow Weller's (1958, p. 633) definition of the term lithofacies in the sense that the Huntington Lithofacies is intertongued with other rocks of the Wabash Formation.

Nearly the entire formation and its two named members were cored in the Northern Indiana Public Service Co. Gale M. and Glada Skinner No. 1 well in northwestern Cass County; this well is here designated as a principal reference section (Appendix, section 7). Exact locations and stratigraphic information for this and other reference sections for the Wabash Formation are given in table 5. Two other reference sections show the formation in reduced thickness where part of the Salina Formation lies in juxtaposition. They are (1) Indiana Geological Survey drill hole 72 in Kokomo, Howard County, and (2) the composite section exposed in the bluffs of the Wabash River between Georgetown and Logansport, Cass County, and cored in Indiana Geological Survey drill holes 97 and 105, (See Appendix, sections 10 and 8 respectively; compare with Cumings and Shrock, 1928a, p. 131-134.)

Four additional principal reference sections in and near the type area of the Wabash Formation are designated as (1) the exposures along both sides of Indiana Highways 13 and 15 just south of the Wabash River and the city of Wabash, Wabash County, which show the Mississinewa Shale and Liston Creek Limestone Members, (2) the railroad cut exposures north of the Big Four Railroad Station in Wabash, which show the Mississinewa. and the so-called classic reef of northern Indiana, (3) the exposure in the Erie Stone Co. quarry on the east edge of the city of Huntington, Huntington County, which shows complex lithologic relationships associated with reef development (Huntington Lithofacies), and (4) the exposure in the May Stone and Sand, Inc. , quarry on the southwest edge of Fort Wayne, Allen County, which shows a reef bank (Huntington Lithofacies) (table 5).

Two other sections designated simply as reference sections are (1) the exposures in the Pipe Creek Stone Co. quarry near Sweetser, Grant County, and (2) the Northern Indiana Public Service Co. Carl Wyneken No. 1 well near Wallen, Allen County (Appendix, section 6). Other characteristic Wabash sections are listed intable 5.

Mississinewa Shale Member.-- The type exposures of the Mississinewa Shale Member of the Wabash Formation are along the Mississinewa River in Wabash and Grant Counties, where as much as 75 feet of this unit can be seen at one place (Cumings and Shrock, 1927, p. 72). In accordance with the most commonly accepted definition that emphasizes its argillaceous and silty nature, the member is about 110 feet thick in subsurface sections in the type area; it is

Table 5.--*Reference and other characteristic sections showing the Wabash Formation*

Reference or other characteristic section	Location			Parts of Wabash Formation shown	Reference
	Sec.	T.	R.		
Principal reference sections:					
1. Northern Indiana Public Service Co. Gale M. and Glada Skinner No. 1 well, near Royal Center, Cass County	NW¼NW¼ 10	28 N	1W	Mississinewa and Liston Creek Limestone Members	Appendix, section 7
2. Indiana Highway 13 road cut south of Wabash and Wabash River, Wabash County	N½ J. B. Richardville Reserve No. 8	27N	6 E	Mississinewa and Liston Creek Limestone Members	Appendix, section 11
3. Big Four Railroad cut in Wabash, Wabash County				Mississinewa Shale Member and reef (Huntington Lithofacies)	Cumings and Shrock (1928a, p. 145-148)
4. Erie Stone Co. quarry just east of Huntington, Huntington County	SE¼ 12	28 N	9 E	Huntington Lithofacies and other rocks associated with reef development	Shaver (1962, p. 77)
5. May Stone and Sand, Inc. quarry southwest edge of Fort Wayne, Allen County	NW¼ 29	30 N	12 E	Huntington Lithofacies in Fort Wayne Bank	Shaver and others (1961, p. 40-42)
Other reference sections:					
1. Indiana Geological Survey drill hole 72 in Kokomo, Howard County	SW¼SW¼ 36	24 N	3 E	Mississinewa Shale and Liston Creek Limestone Members where overlain by Salina Formation	Appendix, section 12
2. Composite section in Wabash River bluffs betw-n Logansport and Georgetown and in Indiana Geological Survey drill holes 97 and 105, Cass County	NW¼NW¼ 32 NE¼SW¼ 36	27 N 27 N	1 E 1 W	Mississinewa Shale Member and Huntington Lithofacies where overlain by Salina Formation	Appendix, sections 10 and 8
3. Pipe Creek Stone Co. quarry near Sweetser, Grant County	NE¼SE¼ 35	25 N	6 E	Mississinewa Shale and Liston Creek Limestone Members	Shaver and others (1961, p. 32, 33)
4. Northern Indiana Public Service Co. Carl Wyncken No. 1 well, near Wallen, Allen County	SW¼SE¼ 11	31 N	12 E	Huntington Lithofacies in Fort Wayne Bank	Appendix, section 6

Other characteristic sections:					
1. Along Mississinewa River, Miami County		26 N	5 E	Liston Creek Limestone Member	Comings and Shrock (1928a, p. 88, figs. 9, 15)
2. Abandoned stream channel on country club grounds in Delphi, Carroll County	SE¼SW¼ 20	25 N	2 W	Huntington Lithofacies and brachiopod *Conchidium* in upper part of formation	Cumings and Shrock (1928a, p. 111)
3. Motion Crushed Stone Co. , Inc, quarry near Motion, White County	NE¼ 28	28 N	4 W	Huntington Lithofacies and other rocks in reef and reef-flank development in upper part of formation	Shaver (1962, p, 78, 79)
4. Standard Materials Corp. quarry at Lapel, Madison County	NW¼NE¼ 28	19 N	6 E	Huntington Lithofacies and other rocks in biohermal development	Shaver and others (1961, p. 46-49)
5. Northern Indiana Public Service Co. Clara J. Boyle No. 2 well, near Thayer, Newton County	SW¼SW¼ 5	31 N	8 W	Entire formation in interreef development undifferentiated to member	Appendix, section 5

about 200 feet thick in its northernmost area of development in Pulaski and Fulton Counties (pl. 1, section C-C'); and as recognized here in far western and southern sections, it is between 50 and 75 feet thick (pl. 1, section B-B'). Stratigraphically the Mississinewa lies above the Louisville Limestone and below the Liston Creek Limestone Member in areas where the Liston Creek is recognized.

The Mississinewa generally is composed of gray fine-grained argillaceous silty dolomite and dolomitic siltstone and minor amounts of pyrite and carbonaceous particles (Appendix, section 12). Powder X-ray traces made from random but characteristic samples show that dolomite and silt generally are about equal in amount. (Also see Cumings and Shrock, 1928a, p. 57.) Horizontal banding in some cores and exposures reflects variation in amount of clay. In many sections of the Mississinewa, this lithology alternates with or is replaced laterally by medium-grained bedded cherty dolomite or dolomitic limestone and coarse- grained massive fossil-fragmental dolomite, lithologies that are respectively characteristic of the Liston Creek Limestone Member and the Huntington Lithofacies.

The lower contact with the Louisville has been discussed; the upper contact with the Liston Creek is sharp in many sections in Wabash and Grant Counties and in a few adjoining counties where light- colored slabby- weathering granular cherty limestone or dolomite of the Liston Creek overlies dark-colored massive uniform Mississinewa rocks. The Mississinewa-Liston Creek contact that is observed in the type areas of these members in Grant and Wabash Counties cannot be traced westward into the subsurface of counties considerably distant, because especially the upper part of the Wabash Formation is not a projection of the Liston Creek lithology seen in the member type areas. In these outlying counties we have placed the upper contact of the Mississinewa at the top of a more or less uniform body of fine-grained argillaceous silty massive dolomite, which lies lowermost in the Wabash, which commonly is less than 100 feet thick, and which underlies a part of the Wabash Formation unassigned to member (Appendix, section 18; pl. 1, section C-C9.

Liston Creek Limestone Member.-- The type exposures of the Liston Creek Limestone Member of the Wabash Formation are along Liston Creek near Red Bridge in southwestern Wabash County (Cumings and Shrock, 1927, p. 75). Here and in adjacent counties where the lower part of the Liston Creek lies at the bedrock surface (Shaver and others, 1961, fig. 3), it consists of light-gray and tan fine- to medium-grained fossil-fragmental cherty limestone and dolomitic limestone. Nodular and bedded chert is most characteristic. The chert is light colored and has relict limestone and fossil structures and replacement boundaries that suggest alteration in both directions between chert and carbonate rock. Where the member is exposed, a slabby appearance is notable. Cores and some fresh exposures lack the slabby aspect and show many thin green argillaceous laminae that appear to be glauconitic or chloritic.

A 1- to 3-foot massive bed occurs at the base of the Liston Creek in Wabash County exposures (Appendix, section 11), where it was called the Red Bridge Limestone Member by Cumings and Shrock (1928a, p. 71). The unit name is here modified to the Red Bridge Limestone Bed of the Liston Creek Limestone Member. The unit is areally restricted and not recognized in the subsurface. These rocks have a reddish cast, which apparently results from the weathering of glauconite.

As originally understood, the unit name Liston Creek Limestone was applied to little more than 30 feet of cherty limestone and dolomite in exposures along the Wabash Valley. These exposures constitute only the lower part of what we now include in the more broadly defined member. Thus it contains as much as 100 feet of rocks in western down-dip sections and is here considered to embrace all the Silurian rocks lying above the characteristically developed Mississinewa Shale Member and below either the Salina Formation (p. 47) or Devonian rocks, provided that these rocks are dominantly cherty and seem to be in continuity with type Liston Creek rocks. Thus some argillaceous and sparingly cherty rocks are included, for example, in Miami, Howard, and Cass Counties. But we have not applied the name to sections in counties farther west where the part of the Wabash Formation that overlies the Mississinewa Shale Member is about 200 feet thick and has complexly superposed and juxtaposed lithologies (pl. 1, section C-C'). A, reference section for the Liston Creek in its expanded definition is designated as the Northern Indiana Public Service Co. Gale M. and Glada Skinner No. 1 well near Royal Center in northwestern Cass County (Appendix, section 7).

Huntington Lithofacies.--The rocks of the well-known reefs, bioherms, and (more recently) banks of northern Indiana are here referred to the Huntington Lithofacies of the Wabash Formation. Hundreds of these structures are known, and only a few appear to have bases lower than the base of the Mississinewa Shale Member. These structures form in part the classic basis for understanding fossil reefs and bioherms (Cumings and Shrock, 1927, 1928a, b). More recently, detailed petrographic studies have been carried on by Carozzi and Zadnick (1959) and Carozzi and Hunt (1960), who outlined parameters for recognizing many microfacies.

Whether having marked structure or lying in horizontal beds and whether designated as reef core, reef flank, or reef detrital, many of the rocks associated with these structures in northern Indiana, along with similar, but regularly bedded, rocks of early to late Niagaran age, have been called the Huntington Dolomite. Cumings and Shrock (1927, p. 78-79) defined the term reef core as “the central unstratified mass against which the inclined strata were deposited and represents the direct constructive work of the reef building organisms. The fossils of the core are nearly always very poorly preserved and often quite unidentifiable.” “Reef core” is very light-gray and gray-mottled fine- to medium-grained saccharoidal (in part) vuggy dolomite; vugs commonly are lined with euhedral dolomite and calcite crystals. The gray mottling tends to be lamellar on fractured surfaces and is interpreted to result from dolomitization of encrusting reef -building organisms, suchasalgae. On exposure this lithology appears in massive interwedged and interlensed units. These rocks are not as common in northern Indiana as so-called reef-flank and reef-detrital rocks.

Concerning flank beds Cumings and Shrock (1927, p. 79) said that “the angle of dip of these beds varies from four or five degrees at the outer margin or periphery of the structure to as much as 65 degrees where they join the core.” Some of the dips probably are not entirely original but have been increased by differential compaction and (or) collapse. (See also Lowenstam, 1950.)

Rocks that are commonly called reef rock but that are reef flank and reef detrital in origin consist of tan and gray fine- to coarse-grained porous vuggy detrital fossil-fragmental limestone and dolomitic limestone showing all stages of recrystallization. Mottling is a function of organic content and degree of dolomitization; organic remains constitute the lighter colored phase.

Most of the “reefs” in northern Indiana are actually bioherms according to Cumings (1933, p. 333) and Curnings and Shrock (1928b, p. 599), who used the term bioherm “for reeflike, moundlike, lenslike, or otherwise circumscribed structures of strictly *organic origin*, embedded in rocks of different lithology.” These masses then, according to this definition, can be products of accumulation as well as products of rigid organic construction. Biohermal rocks lithologically are similar to those described as reef-flank rocks and may have similar origin. Steeply inclined wedges of coarse-grained detrital crinoidal limestone vividly reconstruct the accumulation of fossil debris on the slopes of great embankments. Stromatoporoidal colonies impressively show all stages of recrystallization and transition into crystal-lined cavities (Appendix, section 8) (Shaver and others, 1961, p. 46-49). Impressive as these bioherms are on outcrop, they are dwarfed by some of the reeflike structures in the subsurface south of the study area, in Sullivan and Vigo Counties for example.

Fort Wayne Bank.-- Perhaps the most impressive rock exposure in Indiana is in the May Stone and Sand, Inc. quarry at Fort Wayne, Allen County (NW¼ sec. 29, T. 30 N., R. 12 E.). (See table 5.) In this quarry rocks of the Wabash Formation lie in great interwedged biohermal lenses and biostromal units that are here referred to the Huntington Lithofacies. Cumings (1930b), however, referred these and lower rocks that constitute most of the Niagaran, found in nearby wells, to the Huntington Dolomite. The entire unit, 109 feet thick, appears in the quarry walls as one areally massive unit with even, horizontal top and bottom. Although limited well control across the northern quarter of Indiana precludes our having a detailed distribution pattern, these rocks have more or less continuous linear and digitate extent. They terminate abruptly northward, along slopes near 20 degrees in inclination, against rocks of the Salina Formation. The age relationship is uncertain, although probably there is at least local disconformity, whereas the bank certainly intergrades southward with normal marine rocks of the Wabash Formation, particularly with the Mississinewa Shale Member. This imposing feature that extends in impressive length across the State in a belt 5 or 6 miles wide is named here the Fort Wayne Bank (pl. 1; figs. 4 and 5).

The rocks of the Fort Wayne Bank are mostly gray and blue-gray detrital fossil-fragmental porous vuggy dolomite and dolomitic limestone similar to those rocks already described as reef rock and reef-flank rock. Fine to medium rounded frosted quartz sand and green shale are minor constituents, as they are in many discrete biohermal masses farther south (Appendix, section 6). At some places where control is close, the north slope appears to be inclined about 20 degrees, an inclination which compares closely with the 17- to 20-degree average angle of repose of elastic detrital sediments reported by Pettijohn (1957, p. 168). The inclination of this slope, the texture, and the composition thus favor interpretation of the structural feature as a shelf-edge bank or fringing bank rather than as a barrier reef. A similarly abrupt shelf-edge feature in the Silurian rocks extends from southern Knox County through western Perry County in southwestern Indiana. (See also Lowenstam, 1949, p. 26.)

No discrete Silurian reefs or bioherms are known to occur north of the Fort Wayne Bank in Indiana, but some possibly are present between this bank and similar, older banks in southern Michigan. (Alling and Briggs, 1961, p. 540, fig. 12, depict a generalized “reef barrier system” and “Niagaran reef banks” extending well north into Michigan.) In fact, the bank probably is not as regular a feature as depicted in figure 4; as should be expected in a fringing elastic accumulation, the bank may be irregular and marginally have relief and digitation. It may be in close proximity to discrete structures to the south, and it has been misinterpreted

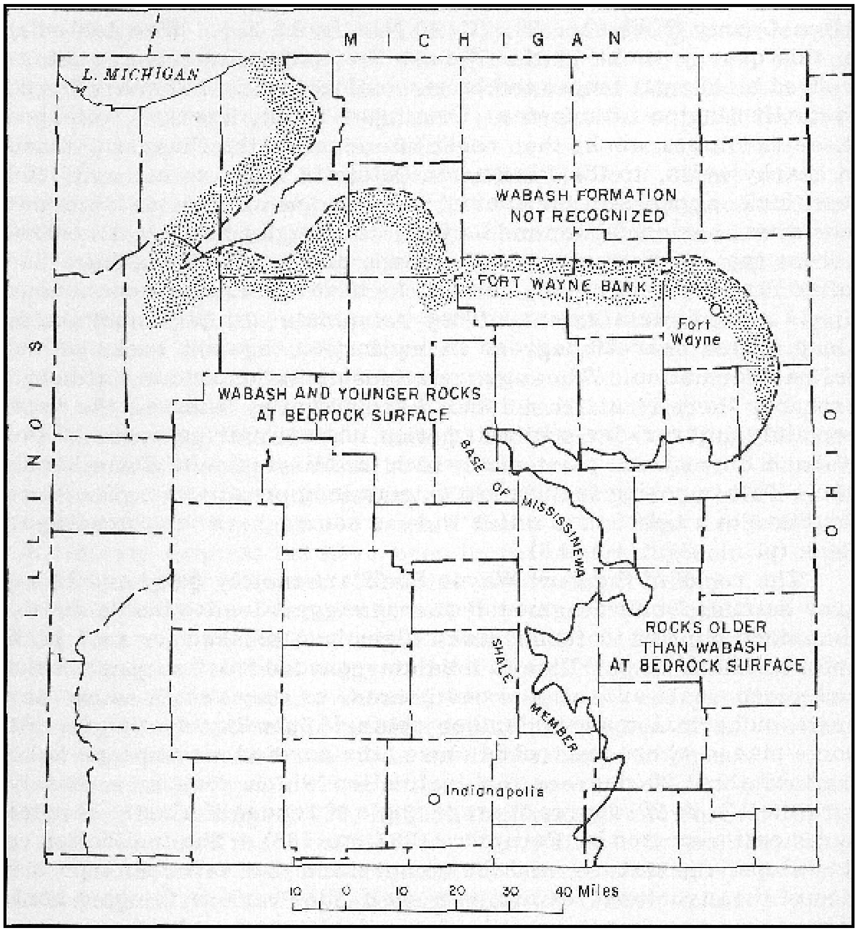

Figure 4. --Map of northern Indiana showing distribution of the Wabash Formation and the Fort Wayne Bank. Limit of the Wabash Formation is shown as a solid line where it is exposed at the bedrock surface and as a dashed line where it is covered by younger rocks.

in places as a pinnacle reef, appearing as such on one, two, or three sides. This feature, however, is not known to have pronounced quaquaversal structure.

Additional well control is needed for proper understanding of geographic extent of the bank and of the relationship to underlying rocks along the northern part of the bank. The Louisville Lime-

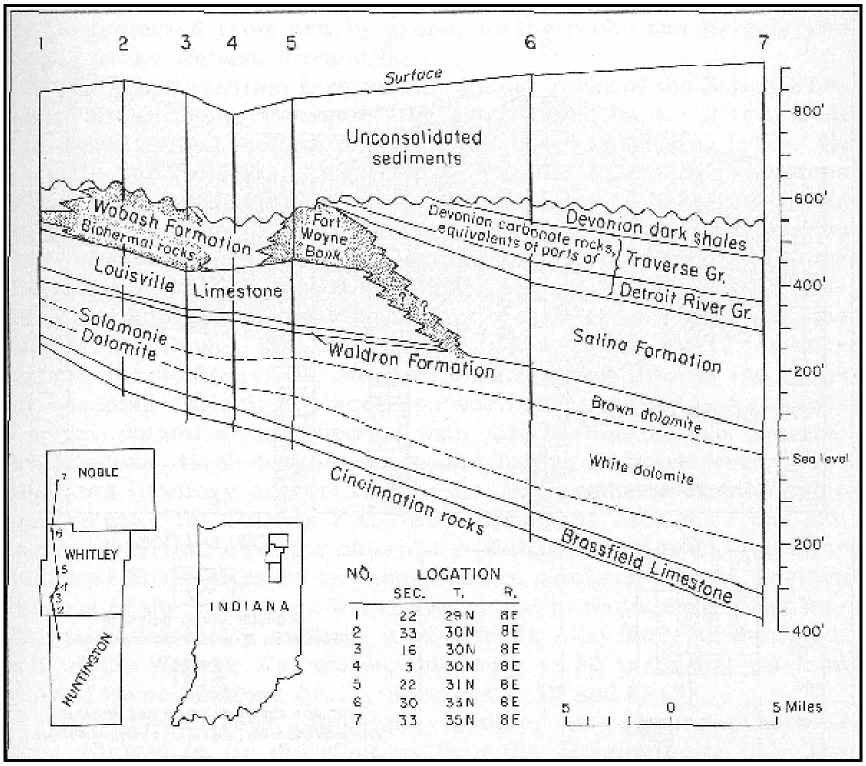

Figure 5. --Cross section from Huntington County to Noble County showing relationships of Silurian rocks at the south edge of the Michigan Basin.

stone, the Waldron Formation, and an upper part of the Salamonie Dolomite extend beneath the southern part of the bank, but along the north margin pure granular vuggy dolomite that is a few hundred feet thick and that has few or no objective criteria for stratigraphic differentiation apparently takes the place of the Louisville, the Waldron, and the upper part of the Salamonie. (See pl. 1, sections A.-A', C-CI, and D-D'; section A-A' crosses only a southern part of the bank.

Distribution.-- Lithologies characteristic of the Mississinewa Shale Member (silty dolomite), the Liston Creek Limestone Member (cherty slabby- weathering dolomitic limestone), and the Huntington Lithofacies (granular vuggy dolomite and limestone) may be compared with end members of a three-phase system. Thus all possible vertical and lateral arrangements of the three lithologies occur in

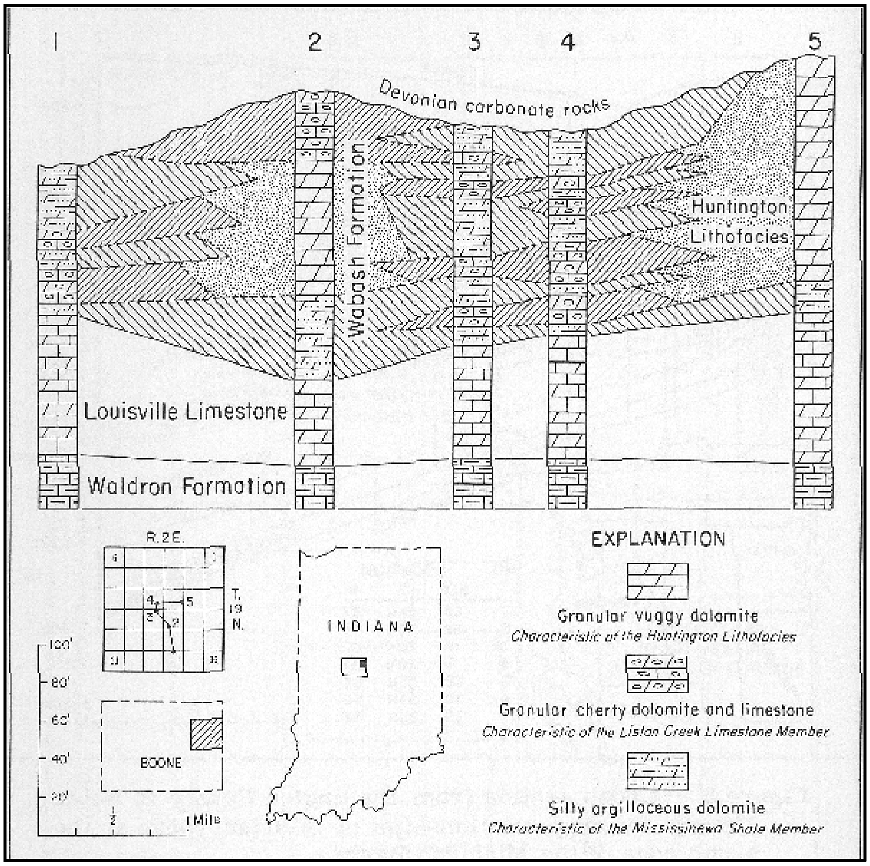

Figure 6. - - Cross section in Boone County showing local relationships of three lithologic varieties of the Wabash Formation.

places in the Wabash Formation as expected from present concepts of reef and interreef sedimentation.

Figure 6 shows that the distribution of the three principal varieties of Wabash rocks must be considered quite apart from the distribution of the formally named parts of the Wabash Formation, particularly in areas distant from the Mississinewa and Liston Creek type areas. Some regionally basic patterns of Silurian sedimentation did exist, however, so that we can speak of regional distribution of the individual members that are locally variable in lithology. Where the member contacts are not recognizable, they can be projected from nearby areas, or the rocks can be referred simply to the Wabash Formation.

The new formation terminates against rocks of the Salina Formation along the north edge of the Fort Wayne Bank. It is absent from east-central Indiana, where it has been eroded (pl. 1; fig. 4).

Although the Mississinewa Shale Member has many gradations between its typical lithology and the Huntington Lithofacies, it can be widely identified in its characteristically silty and argillaceous phase in north-central Indiana. In the northeastern part of the area of Mississinewa occurrence the Huntington Lithofacies of the Mississinewa appears to dominate and merges in some places with the Fort Wayne Bank. (See also Patton, 1955, p. 16, pl. 1, for subsurface distribution of the Mississinewa.) Recognition of the member becomes difficult in places westward, because greater amounts of purer dolomite, interbedded with silty dolomite, are present; nevertheless, thick tongues or lenses having characteristic Mississinewa lithology are present in the Mississinewa stratigraphic position near the Illinois State line (Appendix, sections 5 and 18). For ready definition of the base of the Wabash Formation, the Mississinewa Shale Member is recognized in southern and far western sections of the study area but is restricted to the more or less laterally and vertically uniform argillaceous silty body in the basal part of the Wabash Formation; this zone is 50 to 75 feet thick in many of these sections (pl. 1, sections B-B' and C-C').

The Liston Creek Limestone Member as recognized here is more limited in its distribution than the Mississinewa is. The Liston Creek outcrop belt is displaced westward and northward from that of the Mississinewa because of structure and erosion. Furthermore, the typical Mississinewa- Liston Creek contact-cherty slabby limestone on dolomitic siltstone, which is so marked in Wabash County--is less distinct northeast of Huntington County and southof Madison County (Shaver and others, 1961, fig. 3). The member may be considered, however, to have considerable northward and westward subsurface extent in variable aspect, inasmuch as it is understood here to comprise the uppermost (in the absence of the Salina) Silurian rocks that overlie the Mississinewa in the several counties just westward from Wabash County.

We do not recognize, however, the Liston Creek Limestone Member in the area west of Cass and White Counties or in the far southwestern sections. The Mississinewa Shale Member is thin in these areas, and the uppermost few hundred feet of Silurian rocks are so thick and variable that they do not seem to be properly referable to the Liston Creek, which is little more than 35 feet thick in its Wabash County type area. The Liston Creek is further limited in its distribution, because much of its place is taken by the Salina

Formation in the area of the Logansport Sag (pl. 1, section A-A'; pl. 3).

Rocks of the Huntington Lithofacies are distributed at any level in the Wabash Formation throughout the area of study. Reef and reef-detrital rocks (Huntington Lithofacies) are found not only in the Mississinewa and the Liston Creek, as noted by Cumings and Shrock (1928a), but also in Wabash rocks in the western part of the area that are stratigraphically higher than type Liston Creek rocks (pl. 1, section C-C').

Correlation.-- The Wabash Formation of Indiana corresponds to the upper part of the Thorn Group of northeastern Illinois, as described by Lowenstam, (1949, p. 18; 1950, p. 482), and approximately to the Racine Dolomite of the Chicago area, as described by Willman (1943, p. 58) (fig. 3). One possible interpretation presumes that upper Wabash rocks, in the Fort Wayne Bank for example, are the age equivalents of a lower part of the Salina Formation of far northeastern Indiana and of Michigan, as recognized by Landes (1945) (fig. 3), but faunal evidence is still too scanty to be definitive. Present assignment of rocks to formation is tentative for certain sections, for example those recorded in the Appendix, section 14, unit 2, and section 12, unit 2. Assignment of these and other rocks to either formation leaves the Wabash and Salina Formations in partial juxtaposition with little more evidence than relief on the formational contact and regional distribution on which to determine age relationships. (See the discussion under the heading on description and distribution of the Salina Formation.)

Failure to correlate properly the Huntington Dolomite of many earlier reports has been the greatest obstacle to understanding of Silurian stratigraphy in northern Indiana. A long list of fossils ascribed to the Huntington was brought up to date by Cumings and Shrock (1928a, p. 97) and was augmented by Busch (1939a, b). This fauna was thought by some persons to be Lockport and Guelph in age, but it contains some early Niagaran fossils from rocks that are below the type Huntington and that crop out in east-central Indiana. (See fig. 4 for outcrop area of rocks older than the Wabash Formation, and compare with locations in table 6 from which Huntington fossils were said to have come.)

The stratigraphic concepts presented here, including consideration of the reef and near-reef environments represented by the Huntington Lithofacies, suggest that a great deal of refinement in stratigraphic paleontology is now possible. To this end we have listed revised stratigraphy for most of the older published collecting localities (table 6). We find, for example, that the prolific brachiopod *Pentameras oblongus* is restricted to an older fauna, mostly Salamonie in age, and that species of *Conchidium* are primary indicators of the Huntington Lithofacies (fig. 3), which we consider to be Guelph in age (Ludlow in the British standard, Berry and Boucot, in preparation). These fossil names have been misused, however, and thus we must examine each reported occurrence of these fossils rather than accept the name alone as an age indicator.

The fossil collections at Indiana University contain in the Cumings and Shrock suite the pelecypod *Megalomus canadensis* from the Monon Crushed Stone Co. quarry at Monon in White County (NW¼ sec. 28, T. 28 N., R. 4 W.). (See also Shimer and Shrock, 1944, p. 381.) These rocks stratigraphically are among the highest exposed Niagaran rocks in Indiana (Shaver, 1962, p. 79). This pelecypod was considered by Ehlers and Kesling (1962, p. 11, 15) to be particularly representative of Guelph and late Engadine ages in Michigan and in the upper Great Lakes area. (See also Summerson and others, 1963, p. 42, for *Megalomus* and rocks of probable Guelphage near Toledo, Ohio.) Thus at least the upper part of the Wabash Formation in northwestern Indiana appears to be very high among the rocks conventionally assigned to the Niagaran Series. But Ehlers and Kesling's (1962, p. 12) correlations of the Mississinewa and Liston Creek into Michigan at and near the base of the local Niagaran section seem to be untenable. We suggest that part of the rocks called the Mississinewa and the Liston Creek in southern Michigan are in fact early Niagaran in age (Salamonie in part).

SALINA FORMATION

Definition in Indiana.--The salt-bearing carbonate rocks in the Michigan Basin that have been called the Salina Formation (Landes, 1945) and the Salina Group (Ells, 1962, p. 45; Ehlers and Kesling, 1962, p. 4) attain a maximum thickness in Indiana of about 500 feet (pl. 1, section D-D', and pl. 2B). The name Salina is here applied with formation status to these rocks and accepted for use in northern Indiana. It is used with formation rank because the distribution of possible subdivisions and the relationship of the Kokomo and Kenneth Limestone Members of this report to other Salina rocks are not fully known.

For the most part the south margin of the Salina Formation in Indiana is abrupt along the northward- sloping face of the Fort Wayne Bank where the formation at once overlies and abuts against rocks of Louisville and later age. In two lobate areas, which appear to be structurally controlled, the Salina extends in thin wedges southward from its principal margin. The Salina in Indiana lies upon the Salamonie Dolomite in the area north of the Fort Wayne Bank and upon the Wabash Formation in the lobes south of the bank

Table 6.--*Revised Stratigraphic positions of published fauna from the Silurian rocks of northern Indiana listed by geographic locality*
[Modified from Shaver and others, 1961, p. 25-28.]

Locality	Earlier assignment	Present assignment
Adams County:		
J. W. Karsch quarry, SW¼SW¼ sec. 31, T. 25 N., R. 15 E.	New Corydon Limestone (C&S' C)[1]	Salamonie Dolomite
Smith & Baker quarry, SW¼ sec. 32, T. 25 N., R. 15 E.	New Corydon Limestone (C&S, C)	Salamome Dolomite
	Huntington Dolomite (C&S)	Salamonie Dolomite
Carroll County:		
Camden, NW¼NW¼ sec. 30, T. 25 N., R. 1 E.	Huntington Dolomite (C&S)	Wabash Formation, upper part
Delphi, sees, 19, 20, 29, and 30, T. 25 N., R. 2 W.	Huntington Dolomite (C&S)	Wabash Formation, upper part
Little Deer Creek (same as Camden)	Niagara limestone (K&B)[2]	Wabash Formation, upper part
Cass County:		
Georgetown, Tps. 26 and 27 N., R. 1 W.	Huntington Dolomite (C&S)	Wabash Formation, upper part
Logansport, T. 27 N. , Rs. 1 E. and 1 W.	Kokomo Limestone (C)	Salina Formation
Delaware County:		
Muncie, center sec. 20, T. 20 N., R. 10 E.	Liston Creek Limestone (C&S)	Louisville Limestone
Yorktown, S½ sec. 14, T. 20 N., R. 9 E.	Mississinewa Shale (C&S)	Wabash Formation, Mississinewa Shale Member, lowermost part
	Mississinewa reef (C&S)	Louisville Limestone, uppermost part, and (or) Wabash Formation, Mississinewa Shale Member, lowermost part
Grant County:		
Marion, SW¼ sec. 31, T. 25 N., R. 8 E.	Liston Creek Limestone (C&S)	Wabash Formation, Mississinewa Shale Member?, lower part
Hamilton County:		
Connors Mill, secs. 9 and 16, T. 19 N., R. 5 E.	Liston Creek reef (C&S)	Wabash Formation, upper part?
Fishersburg, sec. 20, T. 19 N., R. 6 E.	Noblesville Dolomite (K&B)	Wabash Formation, middle part?
Helms Mill, secs. 5 and 6, T. 17 N_ R. 6 E.; sec. 32, T. 18 N., R. 6 E.	Noblesville Dolomite (K&B)	Wabash Formation, middle part?
Howard County:		
Kokomo, NE¼ sec. 35, T. 24 N., R. 3 E.	Kokomo Limestone (C&S, C)	Salina Formation, Kokomo Limestone Member
	Mississinewa Shale (C&S)	Salina Formation

Table 6.-Revised Stratigraphic Positions of published fauna from the Silurian rocks of northern Indiana listed by geographic locality-Continued

Locality	Earlier assignment	Present assignment
Huntington County:		
Huntington, sec. 8, T. 28 N. , R. 10 E.	New Corydon Limestone (C)	Wabash Formation, Liston Creek Limestone Member?
Huntington, secs. 7 and 18, T. 28 N. , R. 10 E.	Liston Creek Limestone (C&S)	Wabash Formation, Liston Creek Limestone Member?
Little River, sec. 8, T. 28 N., R. 10 E.	New Corydon Limestone (C&S)	Wabash Formation, Liston Creek Limestone Member?
Little River, secs. 7, 8, and 18, T. 28 N., R. 10 E.	Huntington Dolomite, type section (C&S)	Wabash Formation, Mississinewa Shale Member?, upper part
Markle, Wildcat Reserve No. 37, T. 27 N., R. 10 E.	Liston Creek reef (C&S)	Wabash Formation, Mississinewa Shale Member?
Jay County:		
Jay City, sec. 5, T. 24 N., R. 15 E.	Huntington Dolomite (C&S)	Salamonie Dolomite
Madison County:		
Lapel, sec. 28, T. 19 N., R. 6 E.	Liston Creek reef (C)	Wabash Formation, Mississinewa Shale Member
Pendleton, sec. 20, T. 18 N., R. 7 E.	Noblesville Dolomite (K&B)	Wabash Formation, Mississinewa Shale Member
Miami County:		
Bunker Hill, secs. 19, 29, and 30, T. 26 N., R. 4 E.	Niagara limestone (K&B)	Wabash Formation?
Little Pipe Creek, Peru, SW¼, sec. 29, T. 27 N., R. 4 E.	Mississinewa Shale (C&S)	Wabash Formation, Liston Creek Limestone Member?
Peoria, sec. 4, T. 26 N., R. 5 E.	Liston Creek reef (C&S)	Wabash Formation, near middle
Peru, T, 27 N., R. 4 E.	Liston Creek reef (C&S)	Wabash Formation, near middle
Peru, sec. 20, T. 27 N., R. 4 E.	Mississinewa reef (C)	Wabash Formation, near middle
Seven Pillars, Reserve No. 10, T. 26 N., R. 5 E.	Liston Creek Limestone (C&S)	Wabash Formation, Liston Creek Limestone Member
Randolph County:		
Fairview, NE¼ sec. 11, T. 21 N., R. 12 E.	Huntington Dolomite (C&S)	Salamonie Dolomite, middle part?
Maxville, sec. 20, T. 20 N., R. 13 E.	Huntington Dolomite (C&S)	Salamonie Dolomite, middle part?
Ridgeville, SW¼ sec. 7, T. 21 N., R. 14 E.	Huntington Dolomite (C&S)	Salamonie Dolomite, lower? and middle parts

Table 6.-Revised stratigraphic positions of published fauna from the Silurian rocks of northern Indiana listed by geographic locality-Continued

Locality	Earlier assignment	Present assignment
Wabash County: (general)	Liston Creek Limestone (C&S)	Wabash Formation, Liston Creek Limestone Member and other rocks?
	Mississinewa Shale (C&S)	Wabash Formation, Mississinewa Shale Member
Lagro, T. 28 N., R. 7 E.	Liston Creek Limestone (C&S)	Wabash Formation, Liston Creek Limestone Member
Red Bridge, S½ Reserve No. 26, T. 26 N., R. 6 E.	Mississinewa Shale (C&S)	Wabash Formation, Mississinewa Shale Member
	Liston Creek reef (C&S)	Wabash Formation
Wabash, T. 27 N., R. 6 E.	Liston Creek Limestone (C&S)	Wabash Formation, Liston Creek Limestone Member
	Mississinewa Shale (C&S)	Wabash Formation, Mississinewa Shale Member
Wells County: Bluffton, T. 26 or 27 N. , R. 12 E.	Liston Creek reef (C&S)	Wabash Formation, Mississinewa Shale Member or lower
Rockford, E½ sec. 29, T. 27 N., R. 11 E.	Liston Creek Limestone (C&S)	Wabash Formation, Mississinews Shale Member or lower
White County: Monon, E½ sec. 29, T. 28 N., R . 4 W.	Huntington Dolomite (C&S)	Wabash Formation, upper part

[1]C&S, Comings and Shrock, 1928a; C, Comings, 1930a.
[2]K&8, Kindle and Breger (locations not repeated in Comings and Shrock), 1904.

(Appendix, sections 4 and 10). The Salina in turn is overlain disconformably by Devonian rocks. The Kokomo Limestone and the type Kenneth Limestone of earlier Indiana reports are here accorded member status and are included, along with unnamed parts of the Salina, in the Salina Formation.

Kokomo Limestone Member.-- The term Kokomo was accorded formation status by Curnings and Shrock (1927, p. 76, 77), who followed the suggestion of A. F. Foerste and restricted the name to the lower of two units of Foerste (1904, p. 33), that is, to the eurypterid beds typically exposed below the brachiopod bed (Kenneth Limestone of Cumings and Shrock) in the Markland Avenue Quarry in Kokomo, Howard County. The Kokomo is here assigned the rank of member in the Salina Formation. At its type section (Appendix, section 12) the Kokomo Limestone Member lies on Salina rocks unnamed as to member. The Kokomo consists of banded tan, brown, and gray very fine-grained and thinly laminated dense dolomite and dolomitic limestone. At Kokomo the member is about 50 feet thick. Its distribution in typical lithology south of the Fort Wayne Bank has not been closely defined, and laminated rocks of Kokomo aspect have been observed both uppermost and lowermost in Salina sections 90 feet or more thick (Appendix, section 10). The Kokomo appears to be continuous with the upper brown laminated dolomite in the Salina in the northeast corner of the State (Appendix, section 4).

Kenneth Limestone Member.--The name Kenneth Limestone was applied by Cumings and Shrock (1927, p. 77) to 35 feet of gray and tan lithographic to fine-grained commonly cherty limestone, which is characterized by coquinas of the brachiopod *Coelospira congregata.* The name Kenneth is here accorded member status in the Salina Formation. These rocks overlie thinly laminated Kokomo rocks in the quarry at Kenneth 5 miles west of Logansport, Cass County (Appendix, section 9). The Kenneth Limestone Member of the Salina Formation has been considered to rest disconformably on the Kokomo, but the type Kenneth fossils and the regional interpretation presented here suggest that the rocks of the type section at Kenneth represent a marginal Salina environment. The Kenneth has been recognized also in Howard County, but its distribution is poorly known, and many light-colored coarse-grained fossil-fragmental rocks that have been assigned to the Kenneth in the vicinity of the type section and in other areas may prove to be Devonian in age.

Description and distribution- Like the Kokomo member, the Salina Formation characteristically consists of banded tan, brown, and gray very fine-grained and thinly laminated dolomite and dolomitic limestone. Alternating light and dark laminae average a few millimeters in thickness and result from laminar concentrations of black carbonaceous material, clay, and other noncarbonate detritus; the light- colored laminae are coarser grained than the dark layers. Asphaltic stains, intraformational corrugation and brecciation (Appendix, section 10), and fossil eurypterids are characteristic where the formation is exposed in its Kokomo aspect in Cass and Howard Counties. Dessication cracks, commonly filled with sparry calcite, and stringers and pore fillings of anhydrite and gypsum in the light-colored dolomite are present in some places.

This description characterizes much of the Salina in the northern quarter of Indiana and equivalent rocks in Michigan; many variant rock types are recognized here and elsewhere. Tan medium-grained dolomitic limestone having red-colored grains and green shaly partings has been observed in Starke, Carroll, and Tipton Counties (Appendix, sections 3. and 14). At Fort Wayne sandy and argillaceous dolomites alternate with laminated dolomites (Shaver and others, 1961, p. 42). In Marshall County near its boundary with the Fort Wayne Bank, the formation consists of tan, gray, and brown granular vuggy dolomite in one section (Appendix, section 1), whereas in another section 2 miles distant it consists of tan, gray, and brown granular vuggy dolomites alternating with shaly dolomites (Appendix, section 2). In the northeastern most counties of the State, 100 feet or more of tan granular dolomite is sandwiched between two brown laminated dolomitic units (Appendix, section 4).

Salina rocks are less than 50 feet thick in exposures in Howard, Cass, and Allen Counties but are almost 500 feet thick in the subsurface in northeastern Indiana (pl. 2B). Distribution of the formation and its variation in thickness and lithology are partly functions of structural development during and after deposition of the formation and partly a function of post depositional erosion, both pre- and post- Devonian. Thus the south margin of the area of Salina recognition at the edge of the Michigan Basin is bilobate; one lobe terminates in Tipton, Howard, and Carroll Counties and the other in Newton and Jasper Counties (pl. 2B). These lobes correspond to structurally negative areas that lie across the northwest extension of the Cincinnati Arch (fig. 2). The Salina lies beneath Devonian rocks, but along the crest of the arch erosion has removed part of the Devonian cover and some Silurian rocks. Thus the areas of outcrop and associated thicknesses indicated on plate 2B are considerably generalized, and Salina rocks lie partly in outliers and possibly in inliers. Thinning along the margins of the Salina Formation apparently is much more abrupt than generally depicted on plate 2B, as shown wherever control is adequate. (See fig. 5 for example of abrupt thinning.)

As we have defined the Wabash and Salina Formations in Indiana, their common boundary has considerable relief. Although the position of this contact appears to have been partly structurally controlled, relief is greater than that of lower unit boundaries. This relationship generally has been interpreted as evidence for a Wabash-Salina disconformity, that is, a disconformity at the base of the Kokomo member of the Salina in areas of exposure. (See Cumings and Shrock, 1928a, p. 109, 118, 124, and 131-134, and Shaver and others, 1961, p. 23-24, for earlier discussions of the concept of disconformity.) We remain uncertain of the exact time relationships along the Wabash-Salina boundary, but our observations show that much of the evidence cited earlier for disconformity must be discounted or modified. Proof of disconformity is lacking, as isproof of conformity, and partial contemporaneity of deposition of Wabash and Salina rocks remains a possibility, if not for laterally adjacent sections in close proximity, at least for Wabash and

Salina rocks in widely separated parts of the Michigan Basin. A review of the evidence, which has been cited for disconformity, and newer interpretation of the Salina Formation help to understand distribution of the Salina in its highly variable thickness and lithology.

Regional Salina lithology and thickness are understood best by postulating a condition of progressive southward overlap onto older-to-younger Niagaran rocks. The lower brown laminated Salina dolomite in Steuben, Lagrange, Noble, and De Kalb Counties, mentioned on page 51 and recorded by section 4 of the Appendix, is absent where the Salina thins to 300 feet or less (pl. 2B); southward with rapid thinning across the north side of the Fort Wayne Bank the tan granular dolomite, also mentioned on page 51, is basal, whereas the upper laminated dolomite probably is the unit that extends southward into the central lobate area as the Kokomo Limestone Member of this report (pl. 1, section D-DI). Further, interpretation of the Salina in Indiana as representing marginal phases of a more saline environment accounts for great lithologic variation that has been described and for many probable minor disconformities.

Details of these relationships are seen exposed in only a few places, which are structurally high, in the crestal area of the Cincinnati Arch. The highest reef rocks in the Wabash Formation exposed in northwestern Indiana, as described by Shaver (1962, p. 79) at Monon in White County and by Cumings and Shrock (1928a, p. 178) at Francesville in Pulaski County, are considerably higher than the lowest Salina rocks exposed in the adjacent Salina area of Cass County. This condition prevails for altitudes and for distances above a structural datum (Waldron).

A bioherm near Peru in Miami County, as described by Thornbury and Deane (1955, p. 17), is flanked on the west by limestone of the Kokomo (member of the Salina) and on the east by shaly rocks that they assigned to the Mississinewa (member of the Wabash). In exposures a few miles west of Logansport and along the Wabash River, Cumings and Shrock (1928a, p. 132) described two *Conchidium* bearing reeflike bodies, which they assigned to the Huntington Dolomite, and which they thought had as much as 90 feet of juxtaposition with laminated Salina dolomite, accounted for by disconformity, in exposures no more than 150 feet distant from one of the reeflike masses. At Kokomo, the Kokomo member once was thought to rest disconformably on the Mississinewa with no intervening Liston Creek rocks. The rocks west of Logansport have been cored (Appendix, sections 8 and 10). One of the reeflike bodies has its base in the Wabash Formation and is laterally adjacent to part of the Salina, whereas the one considered to present striking proof of a

Wabash-Salina disconformity is underlain by laminated Salina dolomite and must be assigned to the Salina. The cored section at Kokomo (Appendix, section 12) shows that the Salina in fact rests on the Liston Creek member of the Wabash, and we have here assigned the lowermost rocks in the old exposures at Kokomo, which have been called the Mississinewa, to the Salina. Thus the presumed disconformity described at Kokomo is included within the Salina as we have defined the formation. The pink and varicolored granular dolomitic limestone in Tipton County (Appendix, section 14, units 2-4), also observed in more northern areas (Appendix, section 3, units 6 and 8), appears to lie at the level of both the Salina and the Liston Creek. The Tipton County section, about 100 feet thick, has been assigned to the Liston Creek (Shaver and others, 1961, p. 59), but we here assign it to the Salina. Altogether, these newer observations and stratigraphic practices have resulted in expanding the known areas of Salina distribution at the expense of the Wabash Formation and in the need for new evidence to support the presumed disconformity at the base of the Kokomo.

The Salina contacts with contiguous formations need to be identified by projection of the gross dimensions of the Salina and by specific lithologic criteria which vary from place to place. Characteristically laminated Salina dolomite and shale are definitive, but in far northern Indiana the lower contact is difficult to pick where relatively pure granular dolomite is lowermost in the formation and lies on brown dolomite of the Salamonie. These purer Salina rocks generally are finer grained and less vuggy and uniformly colored than the brown Salamonie rocks, which lie for the most part in predictable thickness above the white dolomite in the Salamonie. In north-central Indiana the lower Salina contact with Wabash rocks also is difficult to recognize in places where marginal Salina rocks consisting of granular fossiliferous carbonate rocks or of indistinctly laminated argillaceous dolomite, lie in proximity to similar Wabash rocks. In these areas the contact generally can be recognized upon examination of the spatial relationships and sequence of lithologies, as we have demonstrated for the sections west of Logansport containing reeflike bodies in both the Salina and Wabash Formations (Appendix, sections 8 and 10). Here, however, and at Kokomo (Appendix, section 12) as another example, lithologies appear to grade through several feet at the critical level, and we have designated contacts in rocks having in between characters. The upper Salina contact with Devonian rocks is discussed beginning on page 56.

Correlation.-- The Salina Formation (Group) of Michigan is subdivided into parts designated as the A unit through the G unit (Landes, 1945; Ells, 1958, p. 32 and 33, and 1960, p. 70). The A unit is the lowest, and most of the Salina of Indiana appears to be a continuation of this unit. According to Ells (1958, fig. 6), however, fringe edges of units as high as the G unit are present in the northeast corner of the State. If our interpretation of overlap by the Salina is correct, the Kokomo Limestone Member possibly represents the upper part of the A unit, designated A2 by Evans (1950, p. 59), but the salt beds that are used in Michigan to subdivide the A unit do not extend as far south as Indiana. The Greenfield Dolomite of Ohio also corresponds in part to the A unit in Michigan and to the Salina Formation in Indiana (Cumings, 1930b, p. 184-189; Alling and Briggs, 1961, p. 524, 525).

In North America the Salina and equivalent evaporite-bearing rocks customarily are placed in the Cayugan Series in the time -rock standard, and the reef-bearing formations are placed nicely below the Cayugan, in the Niagaran Series. Contemporaneity of Salina evaporite deposition and reef development in the Michigan Basin was suggested by Lowenstam (1950, p. 485), less directly in an earlier discussion by Sloss (1947, p. 111), and has been discussed further especially by Liberty and Bolton (1956, p. 168), Alling and Briggs (1961), Melhorn (1958), and by Ells (1958). Our evidence seems to add more to this idea than to the older concept of major disconformity at the base of the Kokomo member or of the Salina. Probably there is at least local disconformity in the Salina areas highest on the Cincinnati Arch, but the age relationships of the Wabash and other Niagaran rocks to the Salina may vary regionally. Both Niagaran and Cayugan time may be represented in the Salina rocks of far northern Indiana and of southern Michigan, as well as in the Wabash rocks that conventionally have been called Niagaran in age, and our Niagaran-Cayugan boundary is placed somewhat arbitrarily in figure 3.

Additional faunal studies are needed to demonstrate the age of many isolated sections of rock that have been considered at different times to be either Silurian or Devonian in age. Especially cored Salina and undifferentiated Niagaran rocks from deeper parts of the Michigan Basin should yield valuable information, when their faunas, possibly of conodonts, are compared with those of rocks from sections on the flank and crestal area of the Cincinnati Arch. The special fauna of the Kokomo, eurypterids, brachiopods, and corals, has not produced uniform paleontologic agreement and has been considered by some persons to be Devonian in age. But there is no evidence to contradict the Silurian age determinations of Cumings (1930a, p. 206) and of Kjellesvig- Waering (1958, p. 295), who (Kjellesvig-Waering) believed that the Kokomo corresponds to the middle part of the Ludlovian Series in British terminology. The Kenneth Limestone Member also has been shunted back and forth;

although two State maps of Indiana (Logan, 1932; Patton, 1956) assign the Kenneth to the Devonian System, the faunal evidence favors a Silurian age, as thought by Kindle and Breger (1904) and Cumings (1930a, p. 207-208: "Decker Ferry-Keyser fauna of NewJersey, Pennsylvania and Maryland"). Further, a type Kenneth fauna characterized by abundant *Coelospira,* collected by G. M. Ehlers and others and filed at the Museum of Paleontology, University of Michigan, also is Silurian in age (Arthur J. Boucot, written communication, June 1, 1961). The large species of the brachiopod *Conchidium* in the reeflike body west of Logansport, described on page 53, is now known to come from Salina rocks rather than from the Huntington Lithofacies, and it is late Silurian (Ludlow in British terminology) in age as are the species of *Conchidium* in Wabash rocks (fig. 3).

UPPER BOUNDARY OF SILURIAN ROCKS

In the northern two tiers of Indiana counties east of Lake County and in parts of the lobate areas of Salina rocks shown on plate 2B, uppermost Silurian rocks belong to the Salina Formation. Elsewhere in the northern half of the State, uppermost Silurian rocks are part of the Wabash Formation. Devonian rocks overlie every component part of these two formations, and well south in the map area their overlap is progressive southeastward onto the eroded edges of older Niagaran units.

The relationship is thought to be everywhere unconformable, and none of the undoubted Devonian faunas, whether from the Geneva Dolomite, Pendleton Sandstone, Jeffersonville Limestone, or unspecified Devonian formations, is yet shown to be older than early middle Devonian in age. Nevertheless, the customary practice of separating Silurian and Devonian rocks remains difficult to invoke in many places. Projection of the regional relationships discussed in this report aids, but detailed faunal (possibly on conodonts) and sedimentologic studies are needed to clarify age relationships in some areas.

Where Wabash rocks are uppermost in the Silurian, argillaceous silty dolomite is more prevalent in the eastern part of the area and coarse-grained vuggy or cherty dolomite is more prevalent in the western part.

North of the crestal area of the Cincinnati Arch in northern Indiana, basal Devonian rocks characteristically consist of dolomite that is gray, fine grained to dense, and more or less sandy. Average thickness of this zone is 10 feet (Appendix, sections 1, 3, and 4). Although transitional upward into more normal tan and gray granular somewhat argillaceous dolomite and limestone, this sandy zone is most important in recognizing the Silurian- Devonian boundary. Recognition of stratigraphic position also aids, and to this end the isopach map of plate 2C has been constructed for the sandy dolomite and the overlying unit of carbonate rocks, which is here considered to be equivalent to part of the Detroit River Group (middle Devonian) of Michigan. The sandy dolomite is included with the overlying carbonate rocks following the practice of Landes (1951, p. 4), who included a basal sandstone in the Detroit River Group in Michigan.

This southward -thinning unit (pl. 20 consists of carbonate rocks, thin shales, and evaporites; lithographic limestone is at or near the top of many sections (Appendix, sections 1, 3, and 4). The lower part of Detroit River rocks in the Michigan Basin, the Amherstburg Formation, pinches out southward northeast of the Indiana- Michigan State line (Landes, 1951, p. 11; Ells, 1958, p. 32, 33), so that the Indiana portion probably corresponds only to the Lucas Formation of Michigan. Both of these and other Devonian Formations in Michigan are underlain by named sandstone members, but correlation of any of these members into Indiana seems tenuous indeed. A similar more or less sandy carbonate rock and sandstone as much as 15 feet thick lies lowermost in the Devonian carbonate sequence in some areas south of the structural axis in Indiana. This is called the Pendleton Sandstone in Madison County (Appendix, section 14), which Ells (1958, p. 16) suggested as a possible equivalent of the Garden Island Formation (lower? Devonian) of Michigan.

Southward -thinning rocks probably equivalent to part of the Traverse Group (middle Devonian) of Michigan are recognized in northernmost Indiana overlying the Detroit River equivalents (pl. 1, sections C-C' and D-D'). Apparently the younger rocks encroach farther south than the underlying unit, and if so, some problematical rocks in Cass, Carroll, Miami, and Howard Counties, commonly referred to the Kenneth Limestone Member of the Salina Formation, possibly represent the Traverse Group.

In northern Indiana rocks equivalent to part of the Traverse Group have been called the Jeffersonville Limestone (Onondaga in age in its type area), Logansport Limestone (Hamilton in age), Sellersburg Limestone (Hamilton in age), and the Hamilton Group. (See Thornbury and Deane, 1955, p. 18, 19.) The name North Vernon Limestone is more appropriate for northern Indiana rocks that are Hamilton in age.

In the south-central part of the area of study, tan fine-grained limestone, probably equivalent to the Jeffersonville Limestone and to part of the Detroit River Group, overlies the Wabash Formation. South of T. 19 N., brown saccharoidal vuggy dolomite, identified here as the Geneva Dolomite (Onondaga in age) (Appendix, section 18) (pl. 1), generally overlies the Wabash Formation.

In parts of Jasper, Newton, Benton, White, and Tippecanoe Counties, middle Devonian rocks consist of dark-brown medium to coarse-grained detrital dolomitic limestone with sandy argillaceous and brecciated phases. These rocks are probably Hamilton in age and appear to represent the Traverse Group.

GEOLOGIC HISTORY

LATE ORDOVICIAN TIME

During all or part of the Cincinnatian Epoch (late Ordovician), a sea extended over the entire area of study in northern Indiana. In the eastern part of the area, and possibly in the western part, sediments were deposited that later became the alternating fossiliferous shales, dolomitic shales, and limestones high in the Richmond Group and uppermost in the Ordovician section in eastern Indiana. Sediments of latest Richmond age were never deposited in northwestern Indiana, or they were deposited and eroded during Richmond and post-Richmond time. In another interpretation, not favored here, the characteristic late Richmond sediments gave way westward in decreasing thickness to the argillaceous and silty materials constituting part of the Maquoketa Shale in western Indiana and eastern Illinois.

A period of nondeposition and erosion followed during latest Ordovician and (or) early Silurian time, conditions brought about, according to Patton (1962, p. 244), by southward tilting and northward truncation of the Ordovician surface of deposition; such truncation also might have had a northwesterly' component and could account for the thinner section of Cincinnatian rocks in northwestern Indiana.

EARLY SILURIAN TIME

A positive structural feature came into existence in the area of study before or during the time of earliest Silurian deposition. It is best interpreted as a shelf in the sense of Eardley (1951, p. 8), extending at least 160 miles across from north to south and constituting a shallow marine area that subsided more slowly and received less sediment than the adjacent, more basinlike areas. The early Silurian shelf is delimited approximately by the area shown in plate 2A as having a more or less uniform thickness of Brassfield and Salamonie rocks and probably extended some northward to about the 300-foot isopach shown on plate 2A. It was broader than and did not coincide throughout with the present crestal area of the Cincinnati Arch in Indiana (fig. 2), although the north edge of the shelf corresponded roughly to the present north flank of tile arch. As indicated by plate 2A, early Silurian subsidence evidently was greater north of the shelf than southwest of the shelf, or the lower Silurian rocks were deposited across an existing structure that had greater relief northward. The sediments now constituting the Brassfield Limestone (Edgewood Limestone and parts of the Kankakee Dolomite in Illinois and the Cataract Formation in Michigan) were deposited probably beginning at an earlier time and under lower energy conditions in northwestern and northern Indiana than in the shelf area southward and southeastward. Thus the lowest Silurian carbonate rocks are thicker and finer grained and seem to have more intimately intercalated argillaceous matter in the northwestern part of the area. Part of the sediment was reworked Ordovician material that is recognizable at places several feet above the Ordovician boundary (table 4). Residual materials in the form of iron compounds were included, but generally conditions were favorable for accumulation of quantities of skeletal sediments, especially crinoidal fragments. Far to the east in North America, sands from the Queenston Delta were swept westward during late Ordovician and early Silurian time. Probably a little of this sand reached the Indiana area to account for the medium to coarse rounded frosted quartz grains that are found in insoluble residues of Brassfield rocks (table 4).

Relative uplift of the shelf, or platform, probably was sporadic; this kind of movement might be interpreted from, and account for, the unconformity that has been suggested as being present at the top of the Brassfield exposures in eastern and southeastern Indiana (fig. 3). This sporadic movement might also account for the thicker and more variable Brassfield sequence in northernmost Indiana, and if the interpretation of some authors (Esarey and Bieberman, 1948, p. 25; Sangree, 1960) is correct, for the absence of the Brassfield on some parts of the shelf in northern Indiana.

EARLY NIAGARAN TIME

During the early part of the Niagaran Epoch (late Alexandrian time in Illinois), a long period of relative stability followed in the study area. On the shallow shelf, as well as in adjacent deeper water, large quantities of skeletal and other (mostly carbonate) debris accumulated to form the Salamonie Dolomite (the Dayton Limestone through the Cedarville Dolomite and probably higher rocks in western Ohio, most of the undifferentiated Niagaran rocks and so-called White Niagaran and Brown Niagaran of the Michigan Basin, and most of the Kankakee and Joliet Dolomites of Illinois). Glauconitic and cherty (or siliceous material contributing to chert) sediments were common, especially during early Salamonie time. These sediments accumulated partly in biostromal and coquinoid deposits, beds of the brachiopod *Pentamerus,* for example, resulting in pure vuggy dolomites and limestones, but there is little or no structural evidence in the area of study that indicates bioherms, reefs, or banks. That some relief was present or that relative growth of the shelf area occurred is indicated by the thicker, although nearly contemporaneous, deposits northward and by gradation southward and westward from relatively pure carbonate rocks in the lower part of the Salamonie to the argillaceous and shaly Osgood Formation and equivalent rocks. (See also Esarey and Bieberman, 1948, p. 33, 34.)

The shelf had a modest westerly component of dip, and possibly Salamonie deposition began in the west before Brassfield deposition was completed in the east. The northwest extent of the stable part of the shelf at this time was in Fulton, Cass, and Carroll Counties as shown by the northwestward thickening of and the nose in the isopach pattern for the combined Brassfield Limestone and Salamonie Dolomite (pl. 2A). Less stable conditions to the northwest produced the variably argillaceous and pure phase in the Kankakee and Joliet rocks of Illinois and equivalent rocks in northwestern Indiana.

A greater thickness of Salamonie sediments accumulated in an elongate area in Fulton and Cass Counties (pl. 2A), which corresponds to the structural saddle known as the Logansport Sag on present-day structure maps (fig. 2). This feature, existing during Salamonie time, is interpreted as a shelf-edge embayment rather than a channel between basins, and it received sediments similar to those on the shelf.

The northerly component of dip on the shelf increased during Salamonie time, so that the basin developing in Michigan and northern Indiana [4] encroached on the shelf from north to south. (See the

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[4] A Silurian basin in northern Indiana was named the Miami Basin by Ehlers and Kesling (1962, p. 8, 13, 16) rather than the Michigan Basin, because they believed that a Mid-Michigan Ridge occupied the center of the present Michigan Basin during middle Silurian time. We must reject the concept of a Miami Basin as presented, however, because the stratigraphic concepts presented here do not support all of Ehlers and Kesling's stratigraphic correlations that led to their structural interpretation.

spacing of isopachs for the sequence of Brassfield and Salamonie rocks on pl. 2A. Note the general agreement between structure on the base of the Waldron Formation (pl. 21)) and that on the Trenton Limestone (fig. 2). At least part of the specific differences result from thickening of the Brassfield and Salamonie rocks, that is, the difference in the amounts of dip down the Trenton structure and down the Waldron structure corresponds approximately to the increment of thickening of the Brassfield and Salamonie rocks between points on the north flank of the shelf.)

MIDDLE NIAGARAN TIME

Near the close of the early part of the Niagaran Epoch and at the end of Salamonie time, muddy sediments crossed the shelf area and resulted in the Waldron Shale in southern Indiana, more shaly to the south but gradually masked to the north to form the thicker Waldron Formation consisting of argillaceous carbonate rocks. Minor and intermittent deposition of muds continued well into the time of deposition of the Louisville Limestone in the shelf area to account for its variably argillaceous, cherty, lithographic, fossiliferous, and fossil - fragmental carbonate rocks.

Evidently, an environment conducive to deposition of the Waldron type of sediment did not exist on the north flank of the shelf, or muds were masked by more rapid carbonate deposition to the north, as interpreted from the fact that the Waldron Formationand the Louisville Limestone cannot be recognized north of the 300foot isopach contour shown on plate 2A. Probably, Waldron and Louisville deposition terminated northward in early growths of the Fort Wayne Bank.

Events are not as clear for northwestern Indiana, but along the northwest side of the shelf in Newton, Jasper, and Starke Counties, a broad channel probably acted during early Niagaran time as an inlet connecting the subsiding northern basin with open sea to the south. The east side of this channel corresponded in position to the present-day Jasper Sag (fig. 2). Interactionof current velocity and depth of water may have contributed to the paucity of the Waldron type of sediment in that area.

The basin north of the shelf continued to subside after deposition of the Waldron and received carbonate sediments, possibly discontinuously in places from Salamonie time and in smaller local increments than the shelf area. In some places these sediments were similar to Salamonie sediments, but regionally they formed the lower part of the Salina Formation at times which were generally earlier northward. This subsidence and upward differentiation of sediment types were accompanied by increased restriction of the channel in Jasper and Newton Counties and by an expansion of the shelf area into northwestern Indiana by time of deposition of the Wabash Formation. (Compare the restricted distribution of the Waldron shown on pl. 2A with the wider distribution of the Wabash Formation shown in fig. 4.)

Possibly incipient reef, bank, or bioherm growth began on the shelf area as early as the time of deposition of the Waukesha Limestone or of the Joliet Dolomite of Illinois, as suggested by Lowenstam (1950, p. 482) and Ingels (1963, p. 409), that is, as early as Waldron and Salamonie time in Indiana, as suggested by Esarey and Bieberman (1948, p. 36).[5] Such early growth on the shelf in Indiana has been postulated earlier only from pure granular vuggy carbonate rocks penetrated by wells and having unknown structural characters and from the locally and extremely abundant fossil remains in pockets near the Laurel-Waldron contact in areas of southern Indiana or in coquinas in the Salamonie. Such accumulations as seen on exposure have only the most gently inclined bedding and slight relief that is measured in inches to a very few feet. A s suggested from the present study, but needing investigation, presently unexposed reefs or reef banks probably began to grow during Salamonie time in far northern Indiana, as they did in southern Michigan, and during Louisville time the lower (northern) part of the Fort Wayne Bank became well established.

LATE NIAGARAN AND EARLY CAYUGAN TIME

Near the close of Louisville time and of the middle part of the Niagaran Epoch in Indiana and somewhat earlier in the adjacent Mercer County area of Ohio, the large bioherms, reefs, and banks, now seen in exposures in the upper Wabash River drainage basin, began to grow on the shelf. During late Niagaran time and along the north margin of the shelf, the more or less linearly continuous deposit of organic detritus called the Fort Wayne Bank attained its greatest growth in the form of great porous interwedged carbonate biostromes. Other organic structures grew in the Mississinewa sea as isolated mounds, which had organically derived rigidity, or which were mechanical accumulations. Their bases were estab-

[5]Structural evidence is needed to substantiate the assumption of major reef growth that Esarey and Bieberman reported for the Salamonie position.

lished at or above the base of the Mississinewa Shale Member of the Wabash Formation in Indiana and mostly within the Racine Dolomite of Willman (1943) in northeastern Illinois. Each kind of niche in the reef and near-reef environment favored certain organisms or assemblages of organisms, so that, for example, stromatoporoids, the brachiopod *Conchidium*, and crinoids flourished in places and contributed to growth of the reef and to modification of their niches. Thus these and other organisms induced the extension of fingers of skeletal debris into the interreef areas. (See Ingels, 1963, for paleocology of the Silurian reef complex in northeastern Illinois.)

Lower energy conditions existed in the interreef areas on the shelf, but interreef sedimentation and reef formation were interdependent, at least in the near- reef areas, and led to complex superposition and juxtaposition of the different rock materials in the vicinities of the reefs. These materials were at once characteristic of Mississinewa and Liston Creek lithologies and of the Huntington Lithofacies, but in limited areas, especially in north-central Indiana, thick interreef deposits of silty carbonate muds (Mississinewa) were followed by granular siliceous carbonate sediments (Liston Creek).

The basin north of the shelf became better defined during Wabash (late Niagaran) and Salina (late Niagaran? and early Cayugan) time. In Indiana this basin received carbonate (partly evaporitic ?) sediments and in Michigan carbonate and evaporite sediments that now constitute a lower part of the Salina Formation (Group). In some places, in Michigan if not in Indiana, part of these materials probably was deposited during the later stages of active reef growth on the shelf in Indiana.

By time of deposition of the Kokomo member of the Salina (probably post-Wabash, in its later duration at least; early Cayugan), the basin had encroached farther southward on the shelf, which by then had an increased northerly component of dip. Two elongate structural depressions, partly evident in the early and middle Niagaran record, indented the shelf toward the southwest, and they constituted the major course of water influx to the southwest corner of the then-restricted basin. One depression occupied the position of the present Logansport Sag, and the other corresponded in position to the present Jasper Sag (fig. 2; pl. 213).

Thinly banded Kokomo and other Salina carbonate sediments consisting of alternating light and dark laminae were deposited in and marginal to the inlets on the basin side. The carbonaceous material in the dark laminae probably flocculated and settled out of suspension or was precipitated out of solution preferentially by charge neutralization of organic ions. Effective change of charge on the suspended particles could have been brought about by changes in salinity of the water, whether or not fluctuations in salinity were seasonally controlled.

In the most marginal or shelfward Salina environment, sediments now constituting tan and red fossil-fragmental dolomitic (in part) limestones with shaly partings were deposited at least in Starke, Carroll, Cass, and Tipton Counties. Evidently the type Kenneth Limestone Member of the Salina also was deposited in a marginal Salina environment in Cass County at a time that probably postdates at least the exposed portions of the Wabash Formation.

LATE CAYUGAN AND DEVONIAN TIME

Probably a greater thickness of Salina rocks was deposited in Indiana during the Cayugan Epoch than is now present in areas of Salina exposures or in areas where Salina rocks are overlain by Devonian rocks. The shelf and basin were uplifted, relatively, after the end of Salina deposition in the State. The pre-middle Devonian erosional surface truncated successively older Silurian formations southward and southeastward on the shelf area. Possibly southward truncation was brought about also by a post-Salina increase in northward tilting, but uniform uplift and removal of a uniformly thick sequence of Silurian rocks also would have effected some southward truncation, because northward structural subsidence and thicker sequences northward were earlier Silurian phenomena.

The time that elapsed between the deposition of Salina rocks and earliest Devonian rocks along the Michigan State line is not precisely known, but the thicker Devonian sequence suggests that it was less than the time represented by the Silurian- Devonian unconformity in exposures in the upper Wabash River area. By early-middle Devonian time restricted basin-type sedimentation had been resumed in the northern part of the former area of Niagaran shelf sediments in Indiana. Sandy, carbonate, muddy, and evaporite sediments were deposited in a southward -thinning wedge in northern Indiana, the south margin of which outlined approximately the present north flank of the Cincinnati Arch, together with the structural modifications called the Logansport and Jasper Sags, the Francesville Dome, and the structural high in Lake County along the Illinois State line. (See isopach map of equivalents of the Detroit River Group, pl. 2C.) During this time the southwest corner of the basin became even more restricted than during Salina time in Indiana, and evaporites constituting as much as 25 percent of the total sediments representing Detroit River time were deposited as far south as the 60-foot isopach contour.

During all the time from late Ordovician to middle Devonian the northwest extension of the Cincinnati Arch had not yet formed as such. Any tendency to form a crest was expressed during Silurian time by the progressive sharpening of the north flank of the platform in central Indiana, that is, the edge of the basin developing in northern Indiana and in Michigan. This accentuation was brought about by negative movement on the north, and any incipient Silurian axis might have had its position and direction shifted in response to several fluctuations that were related to the sedimentary succession as discussed. One such shift occurred at some time after deposition of the Salamonie Dolomite, as can be inferred by comparing plates 2A and 2B.

It was not until after completion of the record recounted here that the Illinois Basin portion of the study area subsided in great enough magnitude to produce the present dips of 35 feet per mile. With this later subsidence, then, came the completion of the structural development of the Cincinnati Arch in Indiana and its subsidiary structures. Post-Devonian erosion produced the distribution pattern of Silurian rocks at the present bedrock surface.

SUMMARY OF STRUCTURAL DEVELOPMENT

1. The southern part of the study area and most of Indiana were part of a broad shallow-water shelf at the beginning of deposition of earliest Silurian sediments. The north and northwest edges of the shelf were delimited during deposition of lower Niagaran rocks by continued subsidence of the area in Indiana and southern Michigan that is now called a part of the Michigan Basin. A broad area of deeper water extended across northwestern Indiana and connected the southwest corner of the basin with open sea to the south.

2. By late Niagaran time, continued subsidence of the basin was accompanied by closing or restricting circulation in all but a small part of the earlier open seaway in northwestern Indiana. The restricted opening occupied the position of the present Jasper Sag.

3. Continued subsidence of the basin on the north during Salina (Niagaran? and Cayugan) time increased definition of limits of the basin and shelf and amplified the minor shelf-edge features, including a restricted opening in the position of the present Logansport Sag and a positive area between the inlets corresponding in position to the present Francesville Dome.

4. The inlets had been closed, for the most part, by Detroit River (Ulsterian) time, and the basin continued to subside during deposition of rocks of Detroit River age, whose boundary coincides

approximately with the south margin of the Michigan Basin in Indiana.

5. Development of the northwest extension of the Cincinnati Arch in Indiana was furthered by Silurian and Devonian subsidence on the north, as the shelf developed an increased northerly component of dip; the present broad crestal feature came into existence later, when the Illinois Basin subsided.

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APPENDIX

Section 1. Description of strip log of core from Northern Indiana Public Service Co. Douglas and Vera L. Marks No. 3 well, near Linkville, Marshall County. Ind. (SE¼NW¼W¼ sec. 12, T. 34 N., R. 2 E.) . Altitude, 830 ft.

	Depth (ft)
Devonian System:	
New Alabany Shale, lower part examined:	
1. Shale, black, carbonaceous	380
No samples	380-410
Unassigned carbonate rocks, 143 ft observed:	
2. Limestone, oolitic and fine-grained, tan; units 2 to 4 are considered to be equivalents of part of the Traverse Group of Michigan	410-424
3. Limestone, dark-brown, brown, and tan, dense	424-440
4. Limestone, shaly, dark-brown, argiilaceous	440-448
5. Limestone, lithographic, tan; units 5 to 7 are considered to be equivalents of part of the Detroit River Group of Michigan	448-458
6. Dolomite in seven alternating intervals of brown or tan fine-grained finely vuggy dolomite and gray dense argillaceous silty (in part) dolomite	458-549
7. Shale, sandy, green and tan, dolomitic in part; sand is fine and composed of rounded quartz grains	549-553
Silurian System:	
Salina Formation, 167 ft:	
8. Dolomite, in alternating intervals of few ft each of brown, tan, or gray dense to fine-grained dolomite	553-594
9. Dolomite, alternating light-tan and gray, fine-grained, very vuggy; unit is brown in lower 6 ft	594-640
10. Dolomite, light-tan, dense to fine-grained, finely vuggy	640-675
11. Dolomite, alternating gray, tan, and brown, dense to very fine-grained, vuggy in part; lower contact picked somewhat arbitrarily	675-720
Salarnome Dolomite, 294 ft:	
12. Dolomite, in alternating intervals of light-gray dense to very fine grained dolomite and white medium-grained vuggy dolomite	720-740
13. Dolomite, white, fine- to medium-grained, very vuggy; has many euhedral crystals; unit corresponds to the White Niagaran of some usage in the Michigan Basin	740-895
14. Dolomite, alternating white dolomite as in unit 13 and gray slightly argillaceous granular dolomite	895-944
15, Dolomite, cherty, gray, very fine-grained, slightly argillaceous	944-985
16. Dolomite, white and as in unit 13; grades to gray very fine grained in lower 10 ft	985-1,014
Brassfield Limestone, 60 ft:	
17. Dolomite, gray, very fine-grained, argillaceous, fossiliferous	1,014-1,024
18. Dolomite, glauconitic, tan, fine- to medium-grained, pyritic in part	1,024-1,045
19. Chert, dolomitic, chalky, iight-tan	1,045-1,049
20. Dolomite, brown, fine-grained; grades to shaly dolomite in lower part	1,049-1,074
Ordovician System, Cincinnatian Series:	
Unassigned rocks, 21 ft examined:	
21. Shale, dolomitic, dark-gray	1,074-1,090
22. Dolomite, tan, medium- to coarse-grained	1,090-1,095

Section 2. Description of strip log of core from Northern Indiana Public Service Co. H. Hawley No. 1 well, near Linkville, Marshall County, Ind, (SW¼SE¼SW¼. sec. 8, T. 34 N., R. 3 E.). Altitude, 808 ft.

	Depth (ft)
Devonian System:	
New Albany Shale, lower part examined:	
1. Shale, black, carbonaceous	315
2, Shale, gray, calcareous	315-335
Unassigned carbonate rocks, 160 ft:	
3. Limestone, dark-brown, medium-grained, fossiliferous; units 3 to 7 are considered to be equivalents of part of the Traverse Group of Michigan	335-349
4. Limestone, oolitic to fine-grained and fossil-fragmental, tan	349-364
5. Limestone, tan and medium-grained in upper part; brown, dense, argillaceous in lower part	364-380
6. Cheri, gray-tan	380-384
7.Limestone, fossiliferous, fine-grained; tan in upper part; brown and gray, argillaceous in low part	384-400
S. Limestone, gray-tan, lithographic; units 8 to 13 are considered to be equivalents of part of the Detroit River Group of Michigan	400-420

	Depth (ft)
Devonian System--Continued	
Unassigned carbonate rocks- -Continued	
9. Limestone, finely sandy, light-tan, fine-grained, argillaceous	420-425
10.Limestone and dolomitic limestone, dark-brown and brown, very fine-grained, argillaccous	425-435
11.Dolomite, argillaccous and silty, light-tan, very fine-grained	435-450
No samples	450-475
12. Dolomite, brown, very fine-grained, pure to argillaccous; has 4-ft interval of sparry calcite in middle part	475-490
13. Sandstone, shaly to dolomitic, green and gray mottled in part	490-495
Silurian System:	
Salina Formation, 153 ft cored:	
14. Dolomite, tan, very fine-grained, silty to pure	495-505
15. Dolomite, shaly, gray-green, dense	505-510
16. Dolomite, alternating gray, tan, and brown in few-ft intervals, fine-grained, finely vuggy	510-560
17. Dolomite, shaly dolomite, and shale (in order of abundance), black, brown, and gray; color banded; much of units 17 and 18 is thinly laminated and has lithology characteristic of the Kokomo Limestone Member	560-595
18. Dolomite, shaly, black and brown	595-620
19. Dolomite, alternating brown, tan, and gray in few-ft intervals, fine grained, finely vuggy; has shaly zone at 640 to 645 ft; to total depth	620-648

Section 3. Description of strip log of cuttings from James L. Black and Anna L. Fentz Charles Kennedy No. 1 well, near Knox, Starke County, Ind. (NW¼SW¼NE¼ sec. 26, T. 33 N., R. 2 W.). Altitude, 710 ft.

	Depth (ft)
Quaternary System:	
1. Surficial materials	0-122
Devonian System:	
New Albany Shale, 53 ft:	
2. Shale, black, carbonaceous	122-175
Unassigned carbonate rocks, 110 ft:	
Not described	175-250
3. Dolomitic limestone, brown, fine-grained, silty and argillaceous in part	250-270
4. Limestone, sandy, clayey, soft; sand consists of fine quartz grains	270-285
Silurian System!	
Salina Formation, 125 ft:	
5. Dolomite, gray and olive-drab, fine-grained, slightly vuggy	285-310
6. Dolomite, pink, fine- to medium-grained; apparently made of skeletal carbonate debris	310-320
7. Dolomite,mottled gray and yellow, fine-grained, finely vuggy	320-330
8. Dolomite, pink, as in unit 6	330-340
9. Dolomite, tan, fine- to mediuni-grained, vuggy	340-360
10. Dolomite, light-gray and tan, very fine-grained	360-410
Salamome Dolomite and Brassfield Limestone, 375 ft:	
11. Dolomite, alternating white, tan, gray, and mottled gray and tan, fine-to medium-grained, vuggy; unit corresponds to the Brown Niagaran of some usage in the Michigan Basin	410-510
12. Dolomite, white, fine- to medium-grained, vuggy; lower 75 ft is very fine grained and saccharoidal in part; upper part corresponds to the White Niagaran of some usage in the Michigan Basin	510-705
13. Dolomite, cherty, glauconitic in upper 10 ft, tan, fine- to medium-grained; has some argillaceous and fossil- fragmental dolomite in lower part to suggest the Brassfield Limestone, but cuttings are badly mixed	705-785
Ordovician System, Cincinnatian Series:	
Unassigned rocks, upper few ft examined:	
14. Dolomite, gray, argillaceous, silty, and tan, coarse-grained, fossil-fragmental	785-

Section 4. Description of strip log of cuttings from Cecil A. Runyan Milton Christlieb No. 1 well, near Sedan, De Kalb County, Ind. (SW¼SW¼NE¼ sec. 11, T. 33 N. , R. 12 E.). Altitude, 870 ft.

	Depth (ft)
Quaternary System:	
1. Surficial materials	0-295
Devonian System:	
New Albany Shale, 83 ft:	
2. Shale, black, carbonaceous	295-378
Unassigned carbonate rocks, 147 ft:	
3, Dolomite, dark-brown, fine-grained; units 3 to 5 are considered to be equivalents of part of the Traverse Group of Michigan	378-384
4. Dolomite, light-tan, medium-grained, cherty	384-412
5. Limestone and dolomitic limestone, brown, tan, and gray, fine- to medium-grained, fossil-fragmental, argillaceous in part; has some light-gray very fine-grained argillaceous dolomite; cherty in lower part	412-450
6. Dolomite, dark-brown, gypsiferous, fine-grained, finely vuggy; gypsum is disseminated in white crystals; units 6 to 9 are considered to be equivalents of part of the Detroit River Group of Michigan	450-458
7. Dolomite, light-gray, sublithographic	458-470
8. Dolomite, dark-brown, gypsiferous, fine-grained, saccharoidal; gypsum is disseminated in white crystals	470-500
9. Dolomite, tan and gray, gypsiferous, fine- to medium-grained; has fine quartz sand grains in upper and lower few ft	500-525
Silurian System:	
Salina Formation, 380 ft:	
10. Dolomite, light gray-tan, fine- to medium-grained	525-560
11, Dolomite, alternating tan, gray, and dark-brown, banded in part, fine-grained, saccharoidal in part, finely vuggy; possibly has gypsum and light-green shale in part; units 11 and 13 have lithology characteristic of the Kokomo Limestone Member	560-665
12. Dolomite, grading down from light-tan to gray-tan, light-gray, and tan, fine-grained, finely vuggy	665-800
13. Dolomite, banded tan, dark-brown, and dark-gray, very fine-grained to fine-grained, saccharoidal in part	800-905
Salamonic Dolomite, 218 ft:	
14. Dolomite, brown, fine-grained, saccharoidal, finely vuggy; unit possibly should be assigned to the Salina Formation but is here considered to correspond to part of the rocks called the Brown Niagaran in the Michigan Basin	905-915
15. Dolomite, white, fine- to medium-grained, very vuggy; has conspicuous euhedral texture in part; unit corresponds to the White Niagaran of some usage in the Michigan Basin	915-1,005
16, Dolomite, white and gray, mottled in part, fine-grained, slightly argillareous in part; has chert from 1, 015 to 1, 020 ft and pyrite in lower part	1,005-1,123
Brassfield Limestone, 89 ft:	
17. Shale and dolomite; shale is light green; dolomite is gray, very fine grained, argillaceous; units 17 to 20 probably correspond to part of the Cabot Head Shale Member of the Cataract Formation of Michigan (Cohee, 1948)	1,123-1,130
18. Dolomite, light-tan, very fine-grained; some dolomite is tan, medium grained, fossil fragmental, argillaceous	1,130-1,153
19. Dolomite, brown, fine- to medium-grained, fossil-fragmental, slightly glauconitic	1,153-1,161
20. Shale, dolomitic, dark-gray	1,161-1,166
21. Dolomite, pink, somewhat ferruginous, fine- to coarse-grained; lower part is lighter colored; unit probably corresponds to part of the Manitoulin Dolomite Member of the Cataract Formation of Michigan (Cohee, 1948)	1,166-1,212
Ordovician System, Cincinnatian Series:	
Unassigned rocks, 38 ft examined:	
22. Dolomite, mottled gray-tan, medium-grained, fossil- fragmental, argillaceous in part; has some dark-gray dolomitic shale	1,212-1,250
23. Dolomitic shale, shaly silty dolomite, and dolomite	1, 250-

Section 5. Log of core from Northern Indiana Public Service Co. Clara J. Boyle No. 2 well, near Thayer, Newton County, Ind. (SW¼SW¼SW¼ sec. 5, T. 31 N., R. 8 W.). Altitude, 642 ft.

	Depth (ft)
Devonian System:	
Unassigned carbonate rocks, 20 ft:	
1. Dolomite in few-ft alternating intervals of variable aspect: gray fine grained argillaceous dolomite having irregular carbonaceous laminae; gray and gray-tan coarse- to fine-grained and saccharoidal finely vuggy (part) dolomite having few shaly laminae; gray fine-grained argillaceous brecciated and recemented dolomite having thin contorted laminae; gray tan and gray fine-grained finely sandy dolomite; has gray and iron-stained finely sandy shale at 100.8 to 101.2 ft; abundant specimens of the conodont genus *loriodus* identified by Carl B. Rexroad in lower 8 ft; includes few ft of core losses	90.0-110.0
Silurian System:	
Wabash Formation, 228. 6 ft:	
2. Dolomite, alternating gray, fine-grained, somewhat shaly, argillaceous, and light tan-gray, fine-grained, porous, cherty	110.0-137.4
3. Dolomite, gray, fine-grained, somewhat shaly; has gray-tan sublitho-graphic cherty dolomite at 153.5 to 158.2 ft	137.4-163.4
4. Dolomite, cherty, gray, fine-grained, argillaceous, somewhat shaly; has patches of gray-tan saccharoidal finely vuggy dolomite and many chert nodules	163.4-196.5
5. Dolomite, gray and light-colored, banded in part, fine-grained, argil-laceous, somewhat shaly; has some chert	196.5-215.5
6. Dolomite, uniform, gray, fine-grained, argillaceous to silty; some chert at 225 to 250 ft	215.5-266.5
7. Dolomite, gray and light-colored, cherty; alternating very fine-grained argillaceous to somewhat shaly dolomite and fine-grained cherty dolomite; unit has many chert nodules, dark-colored partings, and indistinct argillaceous laminae; grades into unit 8	266.5-338.6
Louisville Limestone, 86. 0 ft:	
8. Dolomite, gray; has alternating cherty and argillaceous aspects similar to unit above but distinguished by greater uniformity and fewer shaly partings; somewhat vuggy	338.6-388.7
9. Dolomite and dolomitic limestone, gray; alternating fine- to medium grained cherty dolomitic limestone and very fine-grained argil-laceous dolomite; has green-gray irregular laminae in lower 15 ft	388.7-419.1
10. Dolomitic limestone, gray and gray-tan, fine-grained, somewhat cherty; has half-inch bands of green and black shale in lower 6 in. apparently Waldron equivalent but here is beyond the practical limit of recognition of the Waldron Formation	419.1-424.6
Salamome Dolomite, 180. 2 ft:	
11. Dolomitic limestone, grading down to dolomite, gray with greenish splotches, fine-grained, somewhat argillaceous; has small earthy chert nodules; grades into unit 12	424.6-444.0
12. Dolomite, light-gray, gray, and tan, mottled in part, fine-grained, saccharoidal to medium-grained, finely vuggy; has pure appearance; has sparse earthy chert in upper 30 ft and at 25 ft above base; has few irregular carbonaceous partings; some insoluble residues of rocks of units 11 and 12 contain more than 2,000 and 3,000 specimens per kilogram of ammodiscid foraminifers excluding the genus *Turritella*	444.0-596.5
13. Dolomite, gray, very fine-grained, somewhat argillaceous; has many dark wavy laminae; grades into unit 14; some insoluble residues contain more than 2,000 specimens per kilogram of ammodiscid foraminifers including the genus *Turritella*	596.5-604.8
Brassfield Limestone, 10. 1 ft:	
14. Dolomite; upper part is light pinkish tan, fine grained, saccharoidal; has some thin green laminae and argillaceous intercalations suggesting recemented breccia; grades down to brown and brassy coarse-grained fossil -fragmental vuggy dolomite; has sparse earthy chert; insoluble residues mostly lack foraminifers including all ammodiscids	604.8-614.9
Ordovician System, Cincinnatian Series:	
Unassigned rocks, 14. 5 ft examined:	
16. Shale, dolomitic, dark gray-green, dense	614.9-629.4

Section 6. Log of core (from strip log to 282 ft) from Northern Indiana Public Service Co. Carl Wyneken No. 1 well, near Wallen, Allen County, Ind. (SE¼SW¼SE¼ sec. 11, T. 31 N. , R. 12 E.). Altitude, 827 ft.

	Depth (ft)
Devonian System:	
New Albany Shale, 10 ft cored:	
1. Shale, dark-brown and black, calcareous, carbonaceous	190-200
Unassigned carbonate rocks, 70 ft:	
2. Limestone, alternating tan and gray; argillaceous and dense to medium grained and fossil fragmental; silty in lower 15 ft; lower 5 ft consists of gray dense silty dolomitic limestone	200-270
Salina Formation, Kokomo Limestone Member, 30. 5 ft:	
3. Dolomite, brown, tan, and gray, dense to fine-grained, vuggy and argillaceous in part	270-282.5
4. Dolomite and dolomitic limestone, mostly banded tan, brown, and gray, sublithographic and fine-grained saccharoidal to medium grained and vuggy, thin-bedded; has black carbonaceous sandy (rounded quartz grains) shale in lower 2 in	282.5-300.5
Wabash Formation, 182. 5 ft:	
S. Dolomite, gray and buff, mostly fine-grained saccharoidal, vuggy and having sparry calcite and barite, partly stylolitic; has conspicuous coarse dolornitized fossil fragments; unit constitutes the Huntington Lithofacies in the Fort Wayne Bank	300.5-483.0
Louisville Limestone, 83. 4 ft:	
6. Dolomite, light-brown and some white mottling, fine- to medium grained, saccharoidal in part, very finely vuggy, stylolitic; has white corroded chert nodules and coarse dolornitized fossil fragments; grades into superjacent and subjacent units	483.0-495.4
7. Dolomite and dolomitic limestone in variable aspects, brown, gray, and mottled tan and gray; fine-grained saccharoidal, medium grained, and dense and argillaceous; stylolitic and vuggy in part; has irregular carbonaceous laminae and some white corroded chert	495.4-566.4
Waldron Formation, 35. 7 ft:	
8. Dolomitic limestone, nodular, gray, sublithographic to fine-grained, argillaceous; has black carbonaceous shaly laminae wrapped around nodular components; shale bands are planar and dolomite is brown in lower 2 ft	566.4-602.1
Salamonie Dolomite, 214. 9 ft!	
9. Dolomitic limestone, brown, fine-grained to dense, stylolitic; has shaly partings in upper part and some white corroded chert; unit corresponds to the Brown Niagaran of some subsurface usage in the Michigan Basin	602.1-615.8
10. Dolomite, light-colored, mostly fine-grained saccharcidal and coarsely vuggy; has sporadic white corroded chert and coarse dolomitized fossil fragments; part of unit corresponds to the White Niagaran of some subsurface usage in the Michigan Basin	615.8-817.0
Brassfield Limestone, 24. 6 ft:	
11. Dolomite, argillaceous, gray and gray-green, mostly fine-grained to dense, especially glauconitic in upper part, pyritic, fossiliferous; has intercalations of dolomitic shale	817.0-836.9
12. Dolomite, brown, medium- to coarse-grained, vuggy, ferruginous in lower 6 in	836.9-841.6
Ordovician System, Cincinnatian Series:	
Unassigned rocks, 27. 4 ft examined:	
13. Shale, gray-green; has graptolites	841.6-857.7
14. Shale, dark-gray; has intimate intercalations of light-colored dolomitic limestone composed of fossil fragments; has characteristic Cincinnatian fossils	857.7-862.0
15. Dolomitic limestone, gray and tan, medium- to coarse-grained; has shaly partings and laminae	862.0-869.0

Section 7, Description of strip log of core from Northern Indiana Public Service Co. Gale M. and Glada Skinner No. 1 well, near Royal Center, Cass County, Ind. (NW¼NW¼ sec. 10, T. 28 N., R. I W.). Altitude, 721 ft.

	Depth (ft)
Siluriau System:	
Wabash Formation, Liston Creek Limestone Member, 83 ft:	
1. Dolomite, very cherty, white and light-gray, fine-grained; lower 20 ft is gray argillaceous silty cherty dolomite; chert is white, both fresh and earthy	85-168
Wabash Formation, Mississinewa Shale Member, 162 ft:	
2. Dolomite, gray, silty, argillaceous, fine-grained	168-232
3. Dolomite and dolomitic limestone, both bedded and intimately mixed; dolomite is similar to that of unit 2; dolomitic limestone more prevalent in lower part and is tan with green glauconitic ? mottling, medium grained, fossil fragmental; grades into unit 4	232-330
Louisville Limestone, 64 ft:	
4. Dolomitic limestone, gray-tan and tan, mostly sublithographic, also coarse-grained and fossil- fragmental; has gray argillaceous dense limestone in patches	330-394
Waldron Formation, 13 ft:	
5. Dolomitic limestone, argillaceous to very shaly, brown and dark-gray, sublithographic	394-407
Salamome Dolomite, 161 ft:	
6. Dolomitic limestone, light-tan, very fine- to medium-grained	407-429
7. Dolomitic limestone, mostly white, also gray and pink, fine- to coarse-grained and fossil- fragmental?; lower 6 ft appears to be crinoidal	429-457
8. Dolomite, light-gray, fine-grained, argillaceous and saccharoidal in part	457-486
9. Dolomitic limestone, pinkish-gray, coarse-grained, crinoidal?	486-492
10. Dolomitic limestone and shaly dolomite, mixed, glauconitic in lower part; dolomitic limestone is light tan, mostly coarse grained, fossil fragmental; shaly dolomite is dark gray, dense to coarse grained and pyritic and has fossil fragments	492-513
11. Dolomitic limestone, very cherty, mostly tan, also dark-brown, sub lithographic to fine-grained, argillaceous in darker parts*;* chert is light tan, both fresh and earthy	513-568
Brassfield Limestone, 13 ft:	
12. Dolomite, brown to dark-gray; brown part is fine grained, fossil fragmental?; gray part is argillaceous, dense	568-581
Ordovician System, Cincinnatian Series: Unassigned rocks, 31 ft examined:	
13. Shale, light gray-green, soft	581-583
14. Dolomite, tan and gray; tan part is coarse grained, fossil fragmental?; gray part is argillaceous, dense to medium grained	583-612
15. Dolomitic shale, dark-gray	612 -

Section 8, Log of core from Indiana Geological Survey drill hole 105, near Georgetown, Cass County, Ind. (NE¼NE¼SW¼ sec. 36, T. 27 N., R. I W.). Altitude, 585 ft.

	Depth (ft)
Silurian System:	
Wabash Formation, 214. 5 ft cored:	
1. Dolomitic limestone, splotchy, white and pink to light-tan (above) and gray (below); white and pink part is very coarse grained, fossil fragmental and crystalline, vuggy with calcite spar; tan and gray part has fine-grained and earthy matrix surrounding fossil fragments and be comes dominant in lower part; two varieties intimately intercalated, the finer material filling voids in coarse fraction, which consists of coquinas and fragmented corals, crinoids, brachiopods, gastropods, bryozoans, and especially stromatoporoids; sparingly stylolitic and in varying stages of recrystallization; unit is laterally adjacent to part of the Salina Formation cored 12' miles eastward (Appendix, section 10) but here lies at least partly in the stratigraphic position of the Liston Creek Limestone Member of the Wabash; surface exposures of unit have reef structure (Cumings and Shrock, 1928b, p. 132 and 155); unit constitutes the Huntington Lithofacies of the Wabash and bears the brachiopod *Conchidium cf.. C. knighti*, of Ludlow age (Arthur J. Boucot, written communication, July 3, 1963); grades to unit 2 and includes 6.4ftcoreloss	0.0-109.3

Silurian System-- Continued	Depth (ft)
Wabash Formation- -Continued	
2. Dolomite and dolomitic limestone, splotchy and irregularly banded gray and pink; gray and pink parts as described for unit 1 and also in alter nating beds as much as I ft thick; stromatoporoids dominate; has few slickensided shale seams; units 2 t o 7 (and probably part of unit 1) lie in stratigraphic position of the Mississinewa Shale Member but grade down indistinctly from Huntington Lithofacies to more characteristic Mississinewa lithology	109.3-159.8
3. Dolomite, gray, very fine-grained, earthy, argillaccous; has dark wavy laminae inclined 10 degrees from horizontal as does unit 4	159.8-163.1
4. Dolomite and dolomitic limestone, mostly as unit 2; degree of inter- calation of two types not uniform; coarser grained material mostly recrystallized	163.1-181.3
5. Dolomite, as unit 2; has earthy cherty pods; has laminae inclined at 5 degrees from horizontal	181.3-195.1
6. Dolomite and limestone; dolomite is gray, very fine grained, and argil- laceous and grades to alternating beds of gray and pink coarse-grained fossil- fragmental to crystalline limestone; to total depth	195.1-214.5

Section 9. Composite section in two abandoned quarries of France Stone Co., Kenneth, Cass County (exact center and N½SW¼ sec. 30, T. 27 N. , R. 1 E.). Includes type section of the Kenneth Limestone Member of the Salina Formation. Modified from sections by Carl B. Rexroad, October 1961, and Cumings and Shrock (1928a, p. 134).

Silurian System:	Ft
Salina Formation, Kenneth Limestone Member, 29. 3 ft:	
6. Limestone, cherty, light-gray, dense, irregularly bedded; chert is less abundant downward	17. 3
5. Limestone, light-gray, dense; has irregular nodular bedding in upper part and is laminated in lower part	6.2
4. Limestone, gray, dense, medium-bedded, cherty in upper part	3.0
3. Limestone, fossiliferous, light-gray, dense to very fine-grained; consists of massive bed that has coquinas of brachiopod Coelospira; lower part of the Kenneth in part of northeast quarry appears to be intimately interlensed with underlying Kokomo rocks; Kenneth brachiopods from this location have been identified as Silurian in age (Arthur J. Boucot, written communication, June 2, 1961)	2.8
Salina Formation, Kokomo Limestone Member, 39. 0 ft or more observed:	
2. Dolomitic limestone, banded gray and light-gray, dense to fine grained; to floor of northeast quarry	3.2
1. Dolomitic limestone, banded shades of light gray, gray and brown, dense to fine-grained, thinly laminated; part is vuggy, nonlaminated and granular, and petroliferous; footage given for units 1 to 3 may or may not account for 7 ft of rocks assigned by Cumings and Shrock (1928a, p. 134, unit 7) to the Kokomo; minimum, including rocks in southwest quarry	35.8

Section 10. Log of core from Indiana Geological Survey drill hole 97, near Logansport, Cass County, Ind. (NW¼NW¼NW¼ sec. 32, T. 27 N., R. 1 E.). Altitude, 648 ft.

Silurian System:	Depth (ft)
Salina Formation, 119. 5 ft:	
1. Limestone, pink, fine- to coarse-grained; bedding absent; units 1 to 3 include 7. 9 core loss; units 1 to 5 considered by Curnings and Shrock (1928a, p. 132) to be part of the Huntington Dolomite projecting dis- conformably through the Kokomo Limestone, but two drill holes here penetrated only Kokomo lithology below; units 1 to 5 have brachiopod coquinas of *Conchidium* on exposure	4.8-8.3
2. Limestone, as above, and white fine-grained saccharoidal coarsely vuggy limestone; has asphaltic residue	8.3-13.3
3. Limestone and dolomitic limestone, light-tan and gray, dense to fine grained; bedding absent; has calcite vugs and veins	13.3-18. 1
4. Shale, sandy, gray-green, calcareous; sand consists of fine rounded quartz grains	18.1-20.0
5. Limestone and dolomitic limestone, as unit 3; units 5 and 6 include 11. 0 ft core loss	20.0-(26.3)
6. Dolomite, light-tan, dense to very fine-grained; bedding absent except for indistinctly laminated zone at top; has thin zones of granular vuggy dolomite	(26.3)-40.0

	Depth (ft)
Silurian System- -Continued	
Salina Formation- -Continued	
7. Dolomite ' tan, in alternating zones (in order of abundance) of dense argillaceous indistinctly laminated dolomite, fine-grained saccharoidal finely vuggy thinly laminated dolomite, and fine-grained saccharoidal coarsely vuggy dolomite; units 7 to 10 are characteristic of the Kokomo Limestone Member and here lie in juxtaposition with reef rocks of the Wabash Formation 2 miles west (Appendix, section 8); grades to unit 8 - - - - - - - - - - - - - - - - - - -	40.0-76.5
8. Dolomite, banded brown, gray, and black, thinly laminated, dense and argillaccous to fine-grained; laminae are inclined at angles as much as 15 degrees from horizontal- -	76.5-102.5
9. Breccia, dolomitic, well-cemented; composed of gravel-size to small cobble- size particles of laminated dolomite similar to dolomite of unit 8; has asphaltic residues in vugs -	102.5-109.9
10. Dolomitic limestone, banded brown, dark-gray, and black, thinly laminated, dense to fine-grained, carbonaceous in part; grades to black dolomitic shale in lower few ft -	109.9-124.3
Wabash Formation, Mississinewa Shale Member, 64. 7 ft cored:	
11. Dolomite, mottled gray and buff in vermicular pattern, dense, earthy, argillaceous; parts of unit are reminiscent of Kokomo lithology; grades down to indistinctly banded dolomite, and lower part grades into unit 12 - - - - - - - - - - - - - - - - - - -	124.3-145.9
12. Dolomite and dolomitic limestone, gray, dense, earthy, argillaceous; has zones of dark shaly laminae; has zones of gray medium- to coarse-grained dolomite in upper part; to total depth- -	145.9-189.0

Section 11. Exposure in road cut of Indiana Highway 13 at south edge of city of Wabashand south of the Wabash River, Wabash County, Ind. (Ni J. B. Richardville Reserve No. 8, T. 27 N., R. 6 E.). Modified from section by William J, Wayne, December 7, 1962.

	Depth (ft)
Silurian System:	
Wabash Formation, Liston Creek Limestone Member, 5. 4 ft:	
3. Limestone, pale-yellow, granular, thin-bedded; has wavy partings; somewhat cherty -	4.0
2. Limestone, glauconitic, light yellowish-gray, fine-grained, medium-bedded; glauconite is abundant in discrete dark-green grains; unit is the Red Bridge Limestone Bed -	1.4
Wabash Formation, Mississinewa Shale Member, 48 ft exposed!	
1. Siltstone, dolomitic and argillaceous, light-gray; bedding absent or obsure; weathers brown and shaly, especially along curved joints; has conchoidal fracture- -	46.0

Section 12, Log of core from Indiana Geological Survey drill hole 72, Markland Avenue Quarry (type section of the Kokomo Limestone Member), Kokomo, Howard County, Ind. (SW¼SW¼ sec. 36, T. 24N., R. 3 E.). Altitude, 804 ft. Modified from Shaver and others (1961, p, 13, 14).

	Depth (ft)
Silurian System:	
Salina Formation, Kokomo Limestone Member, 44. 3 ft cored:	
1. Limestone, thinly banded, dolomitic, mostly tan, also gray, buff, yellow, light-brown, and pale-green where dolomitized; conspicuously and uniformly very thin bedded, dense to fine grained; has minor amounts of pyrite, manganese dioxide, clay, stylolites, vertical fractures, and secondary calcite; spottily petroliferous to 42.5 ft; lower part of unit 1 and upper part of unit 2 are equivalent to rocks exposed in the Yeoman Stone Co. quarry at the southeast edge of Kokomo (Shaver and others, 1961, p. 34, 35) -	6.9-51.2
Salina Formation, rocks unassigned to member, 36. 1 ft:	
2. Limestone, cherty, dolomitic, argillaceous in part, mottled light tan gray and dark-gray, fine- to medium-grained, fossiliferous; has thin, indistinct, contorted laminae; has white to gray porcellaneous chert with relict limestone structure from 61. 0 to 79. 5 ft; rocks of unit 2 were called the Mississinewa Shale by Cumings and Shrock (1928a, p. 125) and the Liston Creek Limestone by Shaver and others (1961, p. 13); grades into unit 3- -	51.2-87.3
Wabash Formation, Liston Creek Limestone Member, 38. 2 ft:	
3. Limestone, cherty, mottled tan and gray, medium- to fine-grained downward, fossil-fragmental; blue-gray chert with relict limestone structure common; has minor amounts of pyrite, glauconite, and red fragments -	87.3-125.5

Silurian System- - Continued — Depth (ft)

Wabash Formation, Mississinewa Shale Member, 114. 5 ft:

4. Siltstone, dolomitic, gray, faintly banded, fine-grained; has minor amounts of pyritic and carbonaceous organic fragments -125.5-146.0

5. Dolomite, silty, gray and green-gray with some red coloration at 150 to 154 and 162 to 180 ft, fine-grained, argillaceous, sparingly fossiliferous; thinly interbedded with limestone at 146 to 180 ft and becoming limestone at 197 to 210 and 215 to 240 ft; limestone is tan, fine grained to medium grained, fossil fragmental; most parts of unit faintly banded because of laminar concentrations of argillaceous dolomite; grades into unit 6, and possibly the lower 25 ft should be assigned to the Louisville Limestone -146.0-240.0

Louisville Limestone, 42. 5 ft:

6. Limestone, mottled gray and tan, dense, lithographic in part; sparingly fossiliferous; irregular shaly to elastic carbonate partings and secondarily filled fractures common; has few stylolites -240.0-282.5

Waldron Formation, 10. 0 ft:

7. Limestone, nodular, dense, tan-gray and tan; has many wavy black carbonaceous shaly partings wrapped around nodular components - 282.5-292.5

Salamonie Dolomite, 94. 0 ft;

8. Limestone, dolomitic, conspicuously mottled tan and gray-tan; fine grained to medium grained, fossil fragmental with fine-grained matrix, sparingly stylolitic; secondary recrystallization and associated vugs common below 311. 5 ft; insoluble residues of rocks of units 8, 9, and 10 contain abundant foraminifers comprising the ammodiscids and the genus *Thurammina* in about equal numbers - 292.5-323.5

9. Dolomite, vuggy with associated fossil casts and molds; slighty mottled light gray and gray, porous, transitional to unit above -323.5-362.7

10. Dolomite, cherty, tan, saccaroidal; has green argillaceous partings and glauconitic intercalations near top; chert nodules are white and corroded with light blue-gray cores and relict limestone structure; has shaly partings, small stylolites, and secondary recrystallization; grades into unit 11; unit was assigned to the Brassfield Limestone of Shaver and others (1961, p. 14) but is here considered to lie in the stratigraphic position of the Osgood Formation of southern Indiana -362.7-386.5

Brassfield Limestone, 6.0 ft:

11. Dolomite, tan, fine-grained, glauconitic, noncherty - 386.5-392.5

Ordovician System, Cincinnatian Series:

Unassigned rocks, 14. 3 ft cored:

12. Limestone, tan, mediurn-grained, fossil-fragmental; unit has intercalations of green fossiliferous pyritic shale -392.5-397.0

13. Limestone, gray-tan, fine-grained, fossiliferous; limestone is irregularly interbedded with green and gray fossiliferous shale- -397.0-406.8

Section 13. Type section of the Salamonie Dolomite, consisting of exposure in Rockledge Products, Inc. quarry and core from Indiana Geological Survey drill hole 44, near Portland, Jay County, Ind. (NW¼NW¼ sec. 30, T. 23 N. , R. 14 E.). Altitude at top of cored hole, 835 ft. Modified from descriptions by Dallas N. Fiandt, August 17, 1950, and Shaver and others (1961, p. 58, 59).

Silurian System: — Depth (ft)

Salamonie Dolomite, 135. 2 ft:

1. Dolomite, mottled gray and tan, granular, vuggy, fossiliferous, massive but weathering slabby toward the top; units 1 to 3 are exposed units - - - - - - - - - - - - - - - - - - - 0.0-22.8

2. Dolomite, mottled cream and blue-gray, granular, massive- 22.8-34.6

3. Dolomite, cream, granular, vuggy, massive - 34.6-45.2

No core from altitude 835. 0 to 824. 4 ft - 45.2-55.8

4. Dolomite, light-tan, fine-grained, saccharoidal to coarse-grained, vuggy; bedding indistinct or absent; slightly cherty from 75 to 80 ft - 55.8-85.2

5. Dolomite, light blue-gray, fine-grained, saccharoidal to medium grained, vuggy; has clayey to stylolitic partings; crinoidal fragments abundant in upper part - 85.2-123.3

6. Dolomite, similar to unit 5 but is glaucontic and has light-colored chert nodules; grades into unit 7 - 123.3-135.2

Silurian and Ordovician Systems:

Brassfield Limestone (about 11 ft) and unassigned Cincinnatian rocks (about 14 ft), 25. 2 ft:

7. Dolomite, gray, grading down to brassy-brown in bottom 6. 5 ft, fine to medium-grained, vuggy; has thin laminae and fragments of gray-green shale; Ordovician top picked at 144 to 149 ft on conodonts from insoluble residues - 135.2-160.4

Ordovician System, Cincinnatian Series:	Depth (ft)
Unassigned rocks, 27. 8 ft examined:	
8. Shale, dolomitic, gray-green; has pods and irregular laminae of gray medium-grained dolomite probably replacing bryozoans and other fossils	160.4-163.7
9. Limestone, dolomitic, medium-grained, brassy-brown as part of the rocks of unit 8	163.7-169.8
10. Shale, dolomitic, gray to gray-green; has intervals as much as 0. 8 ft of gray medium-grained dolomite and many pods of dolomite replacing fossils	169.8-188.2

Section 14. Log of core from Indiana Geological Survey drill hole 41, near Groomville, Tipton County, Ind. (NW¼NE¼SE¼ sec. 17, T. 22 N., R. 3 E.). Altitude, 874 ft. Modified from Shaver and others (1961, P. 59, 60).

Devonian System:	Depth (ft)
Pendleton Sandstone, 3 ft cored:	
1. Sandstone, fine-grained, in gray-green argillaceous carbonate matrix; sand grains are clear, well sorted, and rounded	140.0-143.0
Silurian System:	
Salina Formation, 95. 0 ft:	
2. Limestone, fossiliferous, light-tan, fine- to coarse-grained, fossil fragmental, in fine-grained dolomitic matrix; has few petroliferous and calcite-filled vugs and stylolites; fossils consist especially of brachiopods; units 2 to 4 were assigned questionably to the Liston Creek Limestone of Shaver and others (1961, p. 59)	143.0-152.1
Core loss, 152. 1 to 169. 0 ft	
3. Dolomite, gray, dense to fine-grained, saccharoidal	169.0-170.0
Core loss, 170. 0 to 182. 8 ft	
4. Limestone, variably gray, salmon-pink, and tan, mostly coarse grained, fossil -fragmental in gray and tan dense matrix of dolomitic limestone; has patches of coarsely cleavable clear calcite and few irregular green shaly partings	182.8-238.0
Wabash Formation, Mississinewa Shale Member, 102. 0 ft:	
5. Dolomitic limestone, argillaceous, cherty, gray, dense, with some coarse-grained fossil-fragmental beds; has crinoid stems; chert is in small gray and white (corroded) fossiliferous nodules; has many thin indistinct irregular argillaccous laminae; possibly this unit should be assigned to the Liston Creek Limestone Member	238.0-268.2
6. Dolomite, argillaccous, gray, dense; has many tiny silicified fossil fragments near top; grades into unit 7	268.2-340.0
Louisville Limestone, 55. 3 ft:	
7. Dolomitic limestone, gray, medium-grained, argillaceous in part	340.0-356.0
8. Limestone, sublithographic; light tan above becoming strongly mottled dark gray and tan below; has irregular clayey partings	356.0-395.3
Waldron Formation, 10. 3 ft:	
9. Limestone, nodular, dark-gray, dense; has many wavy black carbonceous shaly partings wrapped around nodular components	395.3-405.6
Salamonie Dolomite, 118. 2 ft:	
10. Limestone, dolomitic, gray to gray-pink, medium-grained, fossil-fragmental, in fine-grained dolomitic matrix; has stylolitic partings	405.6-476.6
11. Limestone, dolomitic, with thin green shaly laminae and irregular intercalations; gray tan, medium grained, fossil fragmental, and glauconitic	476.6-483.3
12. Limestone, dolomitic, cherty, tan, dense to coarse-grained; chert is in gray-tan beds and nodules showing corrosion and relict fossil structures	483.3-523.8
Brassfield Limestone, 11. 4 ft:	
13. Limestone, dolomitic, tan grading down to dark-gray, medium-grained; has clayey partings; insoluble residues reveal mixed Ordovician and Silurian conodont faunas in bottom few ft	523.8-535.2
Ordovician System, Cincinnatian Series:	
Unassigned rocks, 19. 4 ft cored:	
14. Shale, dolomitic, or dolomite, argillaceous, gray and gray-green, dense to fine-grained; has characteristic Cincinnatian macrofossils in basal 2 ft	535.2-542.8
15. Limestone and shale; limestone is tan, medium grained to coarse grained, and fossil fragmental and has irregular intercalations of green fossiliferous shale; shale also in beds	542.8-548.8
16. Dolomite, argillaceous, gray-green, dense; has gray irregular pods of crystalline dolomite probably replacing fossils	548.8-554.6

Section 15. Exposure in H and R Stone Co. quarry southeast of Ridgeville, Randolph County, Ind. (SE¼SE¼ sec. 12, T. 21 N. , R. 13 E.). Altitude of quarry floor at base of unit 1,905 ft. Modified from Shaver and others (1961, p. 52).

	Ft
Silurian System:	
Salamome Dolomite, 48. 4 ft exposed:	
4. Dolomite, gray and cream, thin-bedded, fine- to medium-grained, porous, fossiliferous in places; unit appears to be a dolomitized fossil- fragmental oolitic limestone; units I to 4 were called the Huntington Dolomite by Comings and Shrock (1928a, p. 108) and the Cedarville Dolomite and the restricted Huntington by Busch (1939a and b)	6.0
3. Dolomite, fossiliferous, tan-gray, and iron-stained; fine grained and vuggy; fossils consist of molds and casts especially of the brachiopod *Pentamerus oblongus* has few stylolites and is bounded above and below by stylolites	0.9
2. Dolomite, cherty, tan and gray with some lighter colored siliceous bands; fine grained to medium grained, porous, vuggy, and fossiliferous; chert is dark gray to white and porcellaneous with altered rims; gross aspect massive, but thin bedded to medium bedded with stylolites and indistinct bedding planes; basal 4 ft transitional (siliceous; noncherty)	20.0
1. Dolomite, irregularly banded and mottled cream, light-gray, and dark gray; indistinctly to irregularly medium bedded, medium grained, porous, vuggy, and fossiliferous; top of unit makes the first ledge of quarry; exposed thickness	21.5

Section 16. Exposure in abandoned quarry at site of cored hole and logof core from Indiana Geological Survey drill hole 96, near Yorktown, Delaware County, Ind. (SE¼NW¼SW¼ sec. 14, T. 20 N., R. 9 E.). Altitude at top of section, 910 ft.

	Depth (ft)
Silurian System:	
Wabash Formation, Mississinewa Shale Member, 4. 6 ft examined:	
1. Dolomitic limestone, argillaceous, gray and olive drab, dense, earthy, weathering shaly; has conchoidal fracture; units 1 and 2 observed in exposure; this unit and its upward extension of a few feet at this site yielded the graptolites of Curnings and Shrock (1928a)	4.4-9.0
Louisville Limestone, 71. 3 ft:	
2. Dolomite, gray, fine-grained, weathering slabby; has many crinoid fragments	9.0-16.2
No observation	16.2-18.5
3. Dolomite, somewhat mottled light-gray and buff, strongly mottled below 48. 0 ft; has ocherous stains to 42. 0 ft; fine to medium grained, sac charoidal in part, vuggy; unit 3 and lower units observed in core; has lithology similar to that of reefs and, together with unit 2, is involved in local dips, so that Comings and Shrock (1928a, p. 172) designated the site as showing reef development	18.5-58.5
4. Dolomite, mostly buff, fine-grained, and vuggy, argillaceous in upper 2.5 ft, weakly stylolitic; has dark-colored irregular carbonaceous laminae; grades in lower foot to unit 5	58.5-80.3
Waldron Formation, 5. 6 ft:	
5. Shale, dolomitic, dark-gray, especially fossiliferous in lower 6 in. and reminiscent of classic outcrop fossils; has fucoidal markings in part	80.3-85.9
Salamome Dolomite, 85. 7 ft:	
6. Dolomite, light-colored, has ocherous stains in upper part; mostly fine grained saccharoidal; vuggy in upper two-thirds; somewhat stylolitic; has sparse corroded chert in upper part and abundant chert nodules and bands from 126. 5 to 134. 5 ft; upper few inches consist of coquiria of fossils as in unit 5; unit corresponds at least in part to Laurel Limestone of southern Indiana	85.9-134.5
7. Dolomite, argillaceous, gray, earthy, fine-grained; has many crinoid fragments, dark-colored irregular shaly laminae, and white nodular bands of corroded chert; units 6 to 8 correspond at least in part to the Osgood Formation of southern Indiana; grades into unit 8	134.5-151.3
8. Dolomite of variable aspect, gray and light-colored, fine-grained, saccharoidal in part, also coarse-grained, stylolitic and Vuggy in part; has coarse crinoid fragments in upper and lower parts and some dark wavy carbonaceous laminae in lower part; grades into unit 9	151.3-171.6
Brassfield Limestone, 7. 4 ft:	
9. Dolomite, mottled gray and light gray-green, fine-grained, vuggy, pyritic; has some pinkish-tan streaks and crinoid fragments reminiscent of the Brassfield on outcrop	171.6-177.5

Silurian System- -Continued — Depth

Brassfield Limestone- -Continued

10. Dolomite, pyritic, tan and gray and fine- to coarse-grained, also gray green and dense; unit possibly is Cincinnatian m age - 177.5-179.0

Ordovician System, Cincinnatian Series:

Unassigned rocks, 20 ft cored:

11. Dolomite and shale, interbedded and mixed; dolomite is gray and tan, fine to coarse grained, and fossil fragmental and grades to shale; shale is gray green; has characteristic Cincinnatian fossils; unit includes two 3-ft core losses - 179.0-190.0

12. Dolomite, tan to brassy-brown, medium-grained, somewhat vuggy, pyritic; has intercalations of green shale in upper part - 190.0-199.0

Section 17. Log of core from Indiana Geological Survey drill hole 57, near Richmond, Wayne County, Ind. (SW¼SW¼NW¼ sec. 12, T. 14 N. , R. 1 W.). Altitude, 1, 028 ft.

Silurian System: — Depth (ft)

Salamonie Dolomite, 3 2. 1 ft cored:

1. Dolomitic limestone, cherty, mottled gray and tan, fine- to coarse grained, stylolitic; chert is in calcareous bands and nodules from 6. 0 to 22. 0 ft; units 1 to 3 correspond to the Osgood Formation of south ern Indiana, but rocks having the same stratigraphic position and similar lithologies commonly have been called the Brassfield Lime stone in the Indiana subsurface; here they overlie rocks having characteristic Brassfield lithology as seen in southern Indiana exposures - 2.1-22.0

2. Dolomitic limestone, silty, light-gray, fine-grained; has dark slicken- sided shaly streaks - 22.0-27.9

3. Limestone and dolomitic limestone; limestone is mottled dark gray, coarse grained, fossil fragmental; dolomitic limestone is light gray, fine grained, stylolitic, somewhat pyritic and argillaceous - 27.9-34.2

Brassfield Limestone, 8. 3 ft:

4. Limestone, salmon-pink, yellow-brown, and gray, coarse-grained; has brecciated shale and limestone intermixtures; grades to unit 5; base of unit and top of Ordovician rocks picked by means of conodonts from insoluble residues - 34.2-42.5

Ordovician System, Cincinnatian Series:

Unassigned rocks, 17. 6 ft examined:

5. Limestone, gray, coarse-grained- 42.5-46.4

6. Shale, gray-green; has beds of gray to white coarse-grained limestone and intermixed shale and limestone - 46.4-54.6

7. Shale, gray-green, silty, fossiliferous - 54.6-60.1

Section 18. Description of strip log of cuttings from Food Machinery and Chemical Co. Newport Chemical Plant WD-1 well, near Newport, Vermillion County, Ind. (NE¼NW¼ sec. 9, T. 16 N., R. 9 W.). Altitude, 642 ft.

Depth (ft)

Pennsylvanian and Mississippian Systems, rocks not examined to - 1,220

Mississippian and Devonian Systems:

New Albany Shale, 110 ft:

1. Shale, black and gray, carbonaceous - 1,220-1,330

Devonian System:

Unassigned carbonate rocks, 115 ft:

2. Limestone and dolomite, brown, tan, and buff; medium-grained lime- stone grades down to fine-grained argillaceous dolomite; lower 10 ft has rounded quartz grains - 1,330-1,445

Geneva Dolomite, 15 ft:

3. Dolomite, dark-brown, fine-grained - 1,445-1,460

Silurian System:

Wabash Formation, 280 ft:

4. Dolomite and dolomitic limestone, tan grading down to gray, fine- to medium-grained, saccharoidal in part, finely vuggy; unit constitutes a part of the Huntington Lithofacies - 1,460-1,510

5. Dolomite and dolomitic limestone, alternating cherty and noncherty, light-colored to white, fine- to medium- grained, saccharoidal in part, finely vuggy; chert is partly white and earthy at intervals of 1,510 to 1,529, 1,556 to 1,593, 1,624 to 1,642, and 1,655 to 1,665 ft - - - - - - - - - - - - - - - - - - - 1,510-1,665

Silurian System- -Continued — Depth (ft)

Wabash Formation- -Continued

6. Dolomite, grading down from light-colored fine-grained argillaceous pyritic dolomite to gray silty dolomite; unit constitutes the Missis sinews. Shale Member; grades into unit 7 through buff fine-grained dolomite in lower few ft - - - - - 1,665-1,740

Louisville Limestone, 45 ft:

7. Limestone, buff and pinkish-tan, mottled in part, fins- to coarse grained; has pink crinoid fragments in lower part - - - - - 1,740-1,785

Waldron Formation, 5 ft:

8. Dolomitic limestone, brown, sublithographic, somewhat argillaceous- - - - - 1,785-1,790

Salamonie Dolomite, 88 ft:

9. Limestone, dolomitic in part, grading down from tan-gray fine-grained rocks through pinkish-tan to pink coarse-grained crinoidal material in a fine-grained matrix; pink crinoidal rocks in this area and stratigraphic position commonly have been correlated with the St. Clair Limestone of Arkansas and here lie in the stratigraphic position of the Laurel Limestone of southern Indiana - - - - - 1,790-1,855

10. Dolomite, vivid-brown, dirty-looking, fine-grained; units 10 and 11 occupy the stratigraphic position of the Osgood Formation - - - - - 1,855-1,860

11. Dolomite and dolomitic limestone, somewhat glauconitic, cherty, tan, fine- to medium-grained, fossil- fragmental; chert is tan, earthy in part - - - - - 1,860-1,878

Brassfield Limestone, 7 ft:

12. Dolomite, brown, iron-rich, dirty-looking, fine- to medium-grained - - - - - 1,878-1,885

Ordovician System, Cincinnatian Series

Unassigned rocks, 30 ft examined:

13. Dolomite, gray, fine-gramed, silty, argillaceous, pyritic - - - - - 1,885-1,894

14. Shale, dark-gray - - - - - 1,894-1,915

Section 19. Log of core from Indiana Geological Survey drill hole 11, near Westland, Hancock County, Ind. (NE¼SE¼ sec. 28, T. 15 N., R. 8 E.). Altitude, 852 ft. Modified from log by John B. Patton, August 1954.

Devonian System: — Depth (ft)

Unassigned carbonate rocks, 20. 1 ft cored:

1. Dolomite, tan and brown, granular; bedding absent or indistinct; has crystalline calcite intercalations; vuggy in part; becomes very sandy in bottom few feet - - - - - 50.2-70.3

Silurian System:

Wabash Formation, Mississinewa Shale Member, 8.5 ft:

2. Limestone, argillaccous, silty, gray, very fine-grained, pyritic; bedding absent or indistinct - - - - - 70.3-78.8

Louisville Limestone, 27.0 ft:

3. Limestone, gray and tan, mottled and banded, fine-grained, stylolitic- - - - - 78.8-105.8

Waldron Shale, 14. 7 ft:

4. Limestone, argillaceous, gray, fine-grained, fossiliferous - - - - - 105.8-107.3

5. Shale, gray and green-gray, calcareous, fossiliferous in part; bedding indistinct to shaly- - - - - 107.3-120.5

Laurel Limestone, 45. 0 ft:

6. Limestone in several discernible units as much as a few feet thick; variably light gray, dark gray, gray and tan mottled, gray; cherty and noncherty; fine grained to coarse grained; stylolitic in part- - - - - 120.5-165.5

Osgood Formation, 17. 2 ft:

7. Limestone, banded and mottled gray and tan to tan throughout, dense and argillaceous to coarse-grained; thin bedded in part - - - - - 165.5-175.5

8. Shale and interbedded shale and limestone; shale is green, calcareous, fossiliferous, and thinly interbedded in part with argillaceous limestone- - - - - 175.5-182.7

Brassfield Limestone, 9. 6 ft:

9, Limestone, tan, dark gray-brown and tan, medium- to coarse-grained, glauconitic, fossiliferous and stylololitic in part; has wavy argillaceous partings - - - - - 182.7-192.3

Ordovician System, Cincinnatian Series:

Unassigned rocks, 28. 0 ft cored:

10. Shale, green-gray, calcareous, fossiliferous; has thin intercalations of fossiliferous limestone- - - - - 192.3-195.4

11. Shale, grayish olive-green, noncalcareous- - - - - 195.4-215.1

12. Shale and limestone, thinly interbedded, fossiliferous; shale is gray and calcareous; limestone is dark gray and coarse grained - - - - - 215.1-220.3

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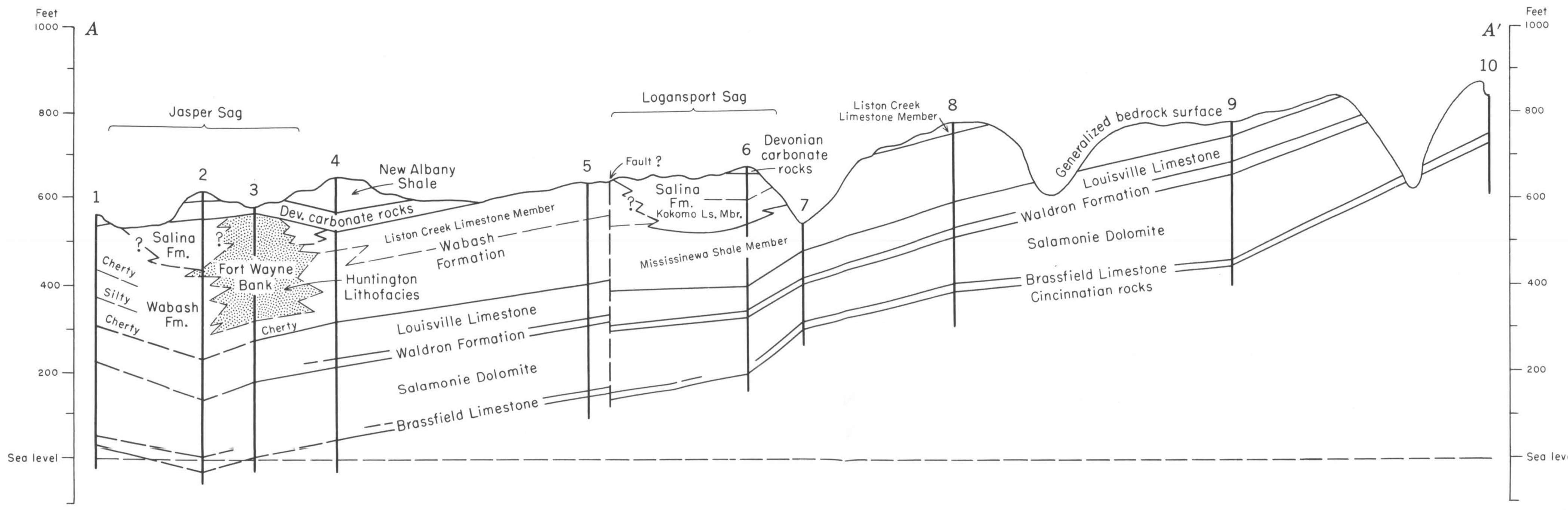
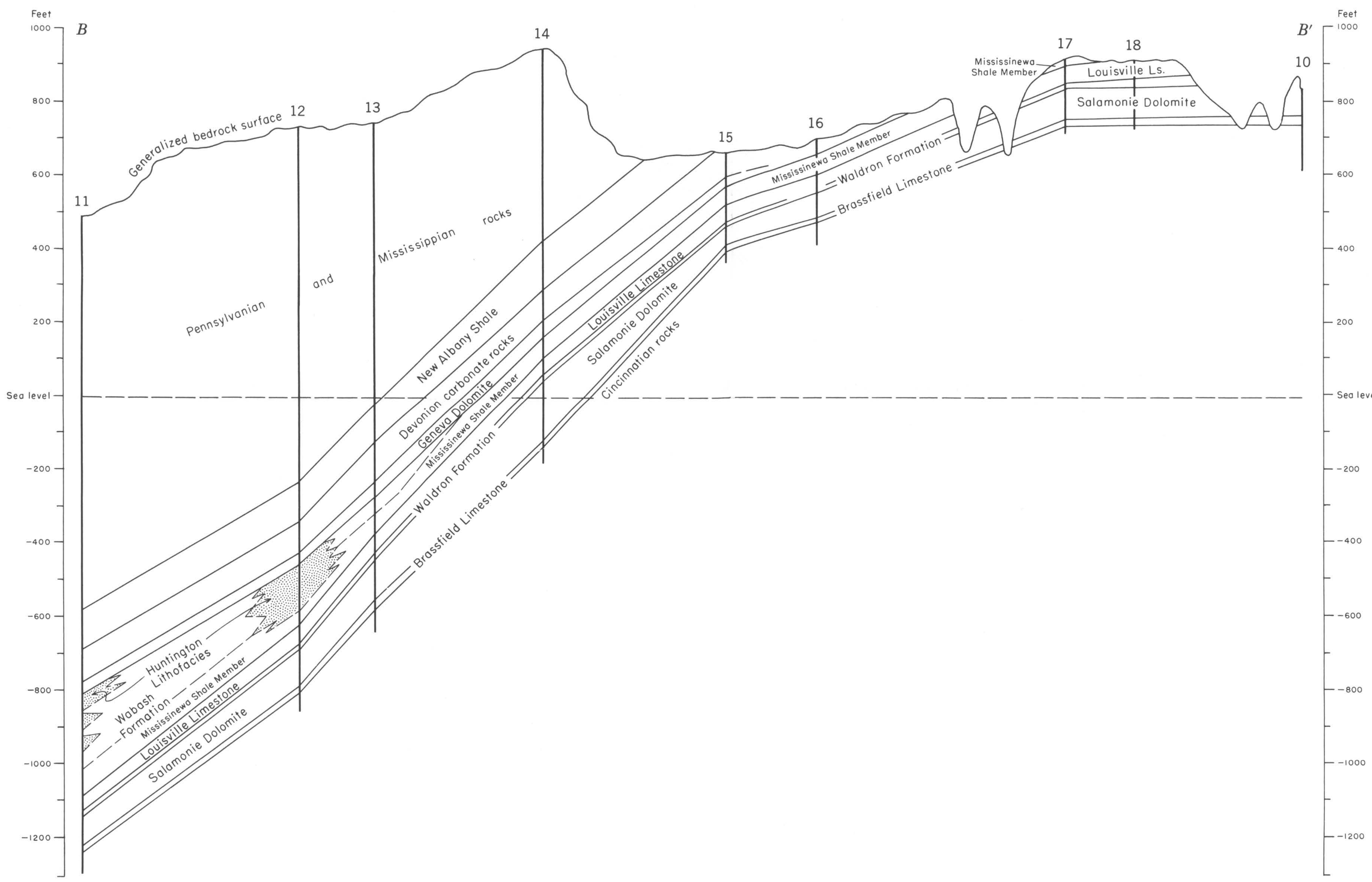


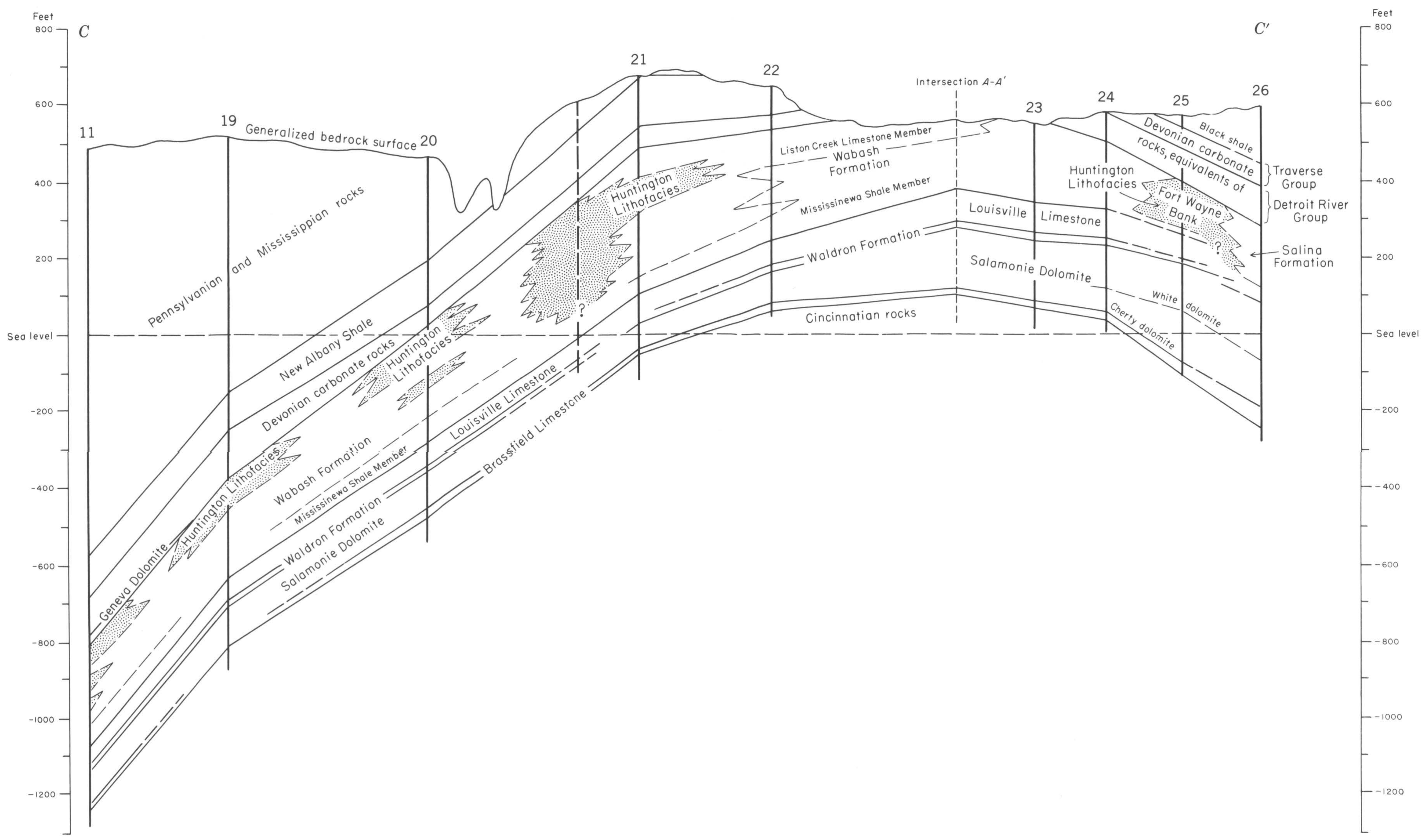


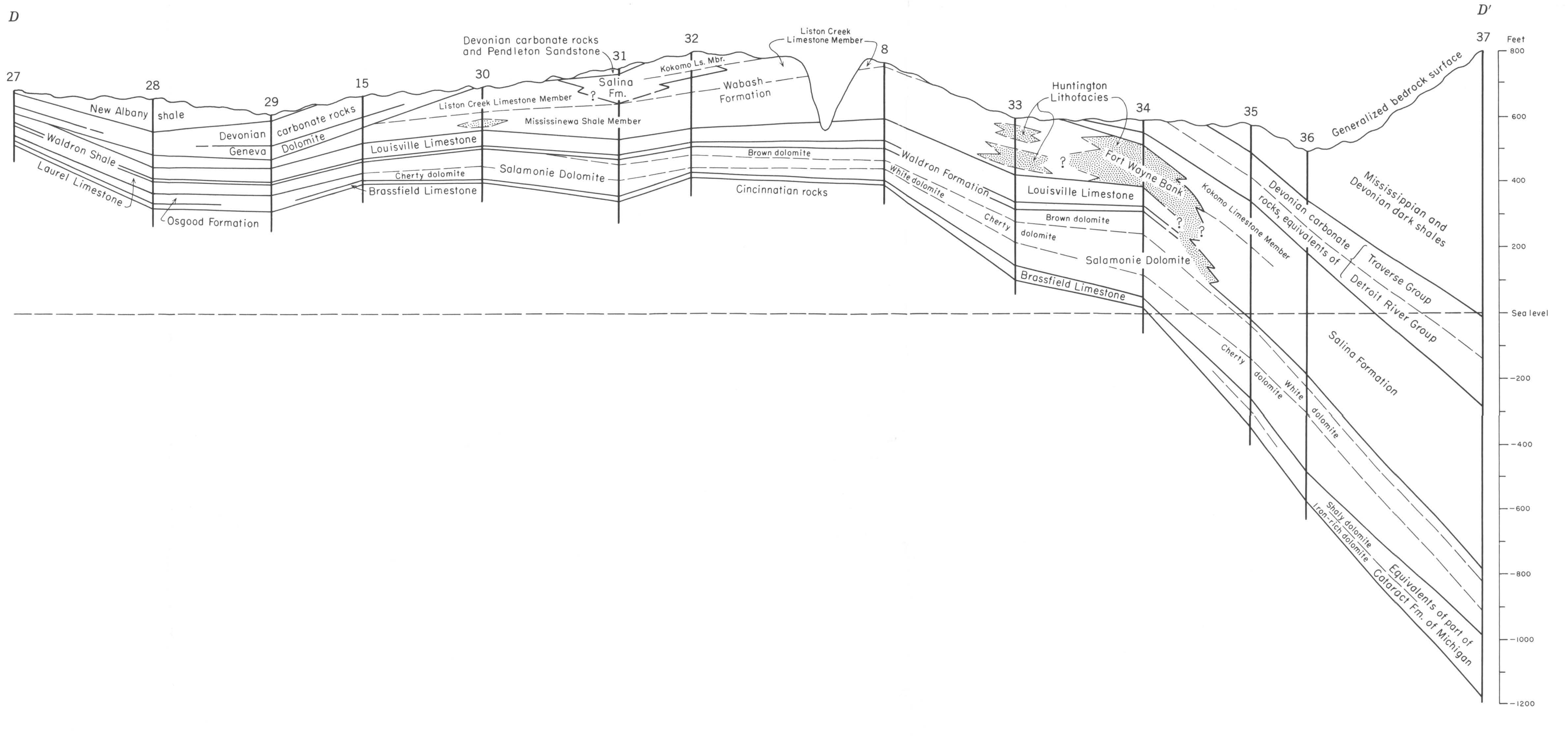
LOCATIONS OF WELLS

No.	County	Sec.	Location T.	R.	Driller	Well
1	Newton	5	31 N	8 W	Northern Indiana Public Service Co.	Clara J. Boyle No. 2
2	Jasper	25	30 N	7 W	A. C. Thomas	Amos Davisson No. 1
3	Jasper	14	30 N	6 W	Kankakee Valley Development Co.	State Bank of Rensselaer No. 1
4	Jasper	24	31 N	5 W	Charles A. Davis	Ralph Ballard No. 1
5	Cass	10	28 N	1 W	Northern Indiana Public Service Co.	Gale M. and Glada Skinner No. 1
6	Cass	*	27 N	3 E	Donald E. Fredenhagen	Celia Casebeer No. 1
7	Miami	21	27 N	4 E	Harry A. Raider, Jr.	James A. Mills No. 3
8	Wabash	17	27 N	7 E	Charles Clemens	E. and A. Stouffer No. 1
9	Wells	4	27 N	12 E	Robert Bond	C. C. and Ona Gibson No. 1
10	Jay	30	23 N	14 E	Indiana Geological Survey	Drill hole 44
11	Vermillion	9	16 N	9 W	Food Machinery and Chemical Co.	Newport Chemical Plant No. WD-1
12	Putnam	15	14 N	5 W	Stanolind Oil & Gas Co.	Ross P. Wells et al. No. 1
13	Putnam	17	14 N	3 W	Hayes Drilling Co.	John and Nancy Nichols No. 1
14	Morgan	22	13 N	1 E	C. E. Weddel	Melvin Fuller No. 1
15	Marion	18	16 N	4 E	Indiana Geological Survey	Drill hole 35
16	Hancock	6	16 N	6 E	(Seip) Chafee	Ira Brock No. 1
17	Delaware	14	20 N	9 E	Indiana Geological Survey	Drill hole 96
18	Delaware	25	21 N	10 E	Irving Bros. Gravel Co., Inc.	No. 1
19	Fountain	16	19 N	8 W	Aldridge-Banta	Alma Bodine No. 1
20	Warren	24	23 N	10 W	Detrick & Topf	James Bowman No. 1
21	Newton	22	27 N	8 W	National Petroleum Co.	Chester Bokma No. 1
22	White	33	27 N	5 W	Marion B. Oglesby	Lewis Helderle No. 1
23	Pulaski	10	30 N	1 W	Continental Oil Co.	W. L. Peters No. 1
24	Fulton	14	31 N	1 E	Continental Oil Co.	William Krafft No. 1
25	Marshall	36	33 N	1 E	Continental Oil Co.	Emil C. and Florence Krull No. 1
26	Marshall	12	34 N	2 E	Northern Indiana Public Service Co.	Douglas and Vera L. Marks No. 3
27	Bartholomew	5	8 N	7 E	Indiana Geological Survey	Drill hole 21
28	Johnson	17	11 N	5 E	Indiana Geological Survey	Drill hole 20
29	Marion	23	14 N	4 E	A. W. Rea and E. C. Steckler	Ural Pierce No. 1
30	Hamilton	19	19 N	4 E	Boyd Huff and Thurl C. Rhodes	Roy Wood et al. No. 1
31	Tipton	17	22 N	3 E	Indiana Geological Survey	Drill hole 41
32	Howard	36	24 N	3 E	Indiana Geological Survey	Drill hole 72
33	Whitley	16	30 N	8 E	Carter Oil Co.	Harvey and Geneva Kreider No. 1-S
34	Allen	5	31 N	11 E	G. C. Parker and J. A. Chapman	Ray and Helen Ashbaugh No. 1
35	De Kalb	11	33 N	12 E	Cecil A. Runyan	Milton Christlieb No. 1
36	De Kalb	36	35 N	12 E	Garland Mullendore	Peter Sebert No. 1
37	Steuben	17	38 N	15 E	Fay Woodruff and Basil Jenkins	O. and A. Weicht No. 1

*J. B. Richardville Reserve.

MAP OF INDIANA SHOWING LOCATIONS OF WELLS AND CROSS SECTIONS





Drafted by Betty Marzan

CROSS SECTIONS SHOWING CORRELATION AND STRUCTURE OF SILURIAN ROCKS IN NORTHERN INDIANA

By Arthur P. Pinsak and Robert H. Shaver

1964

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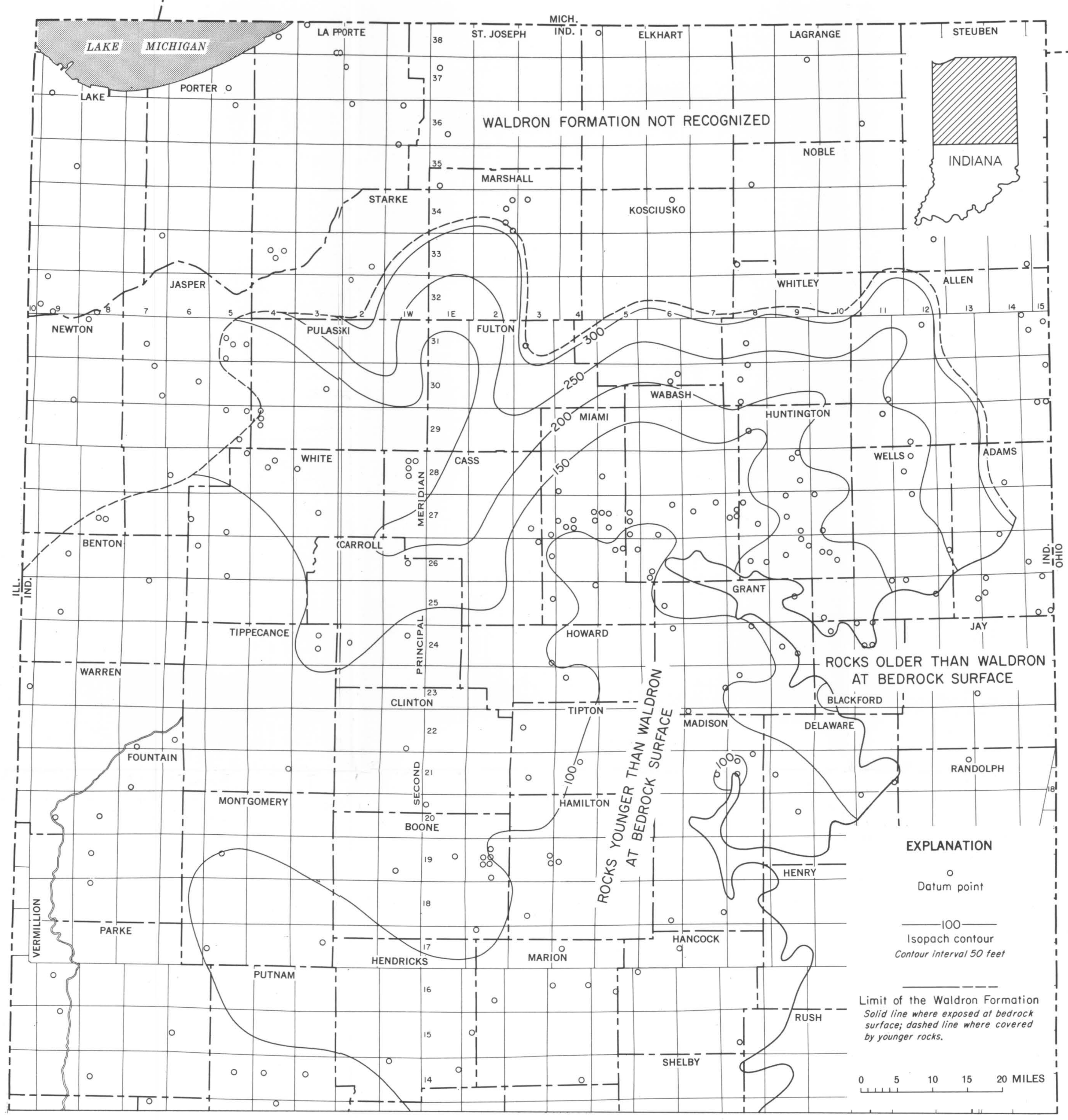
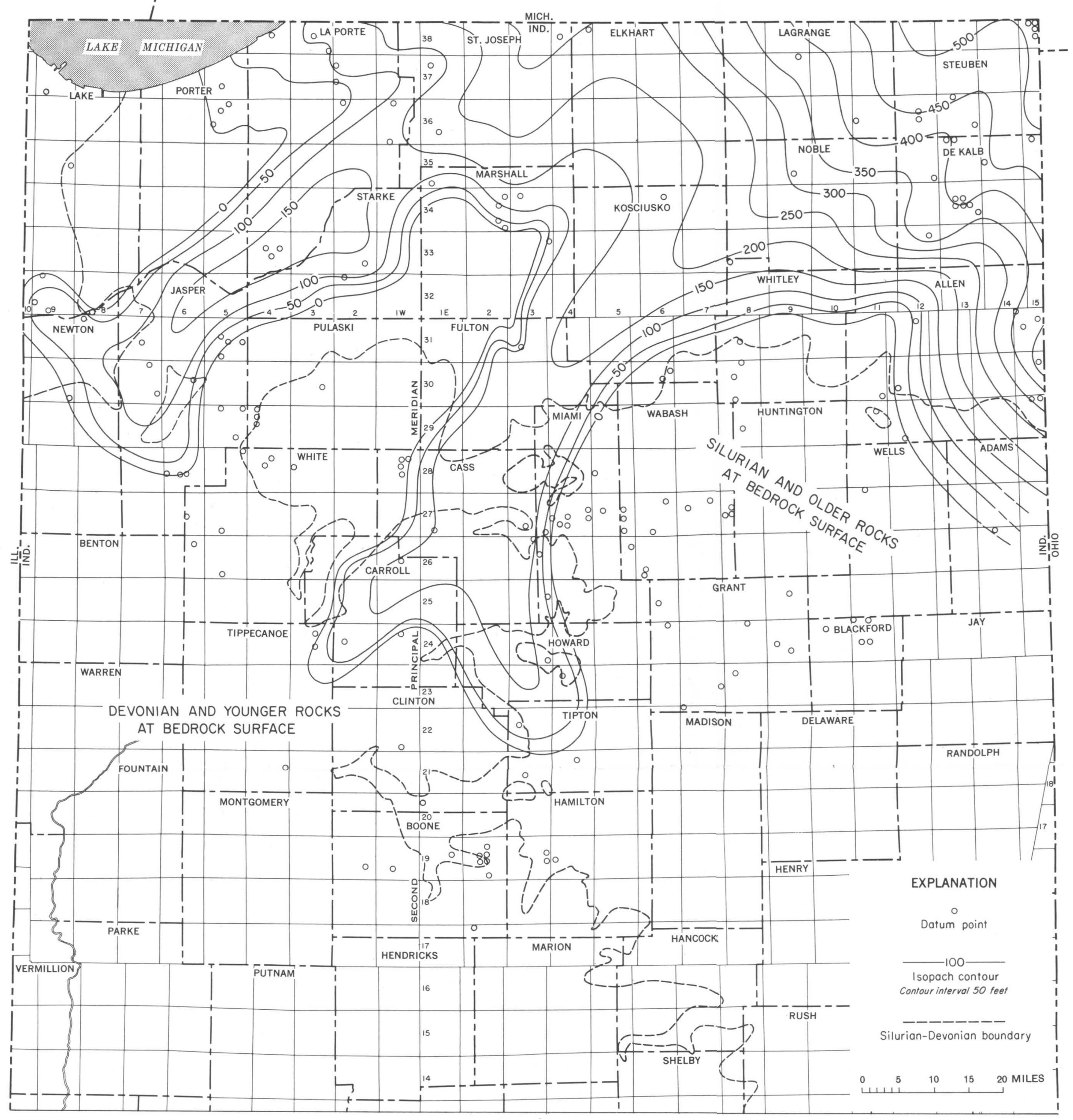
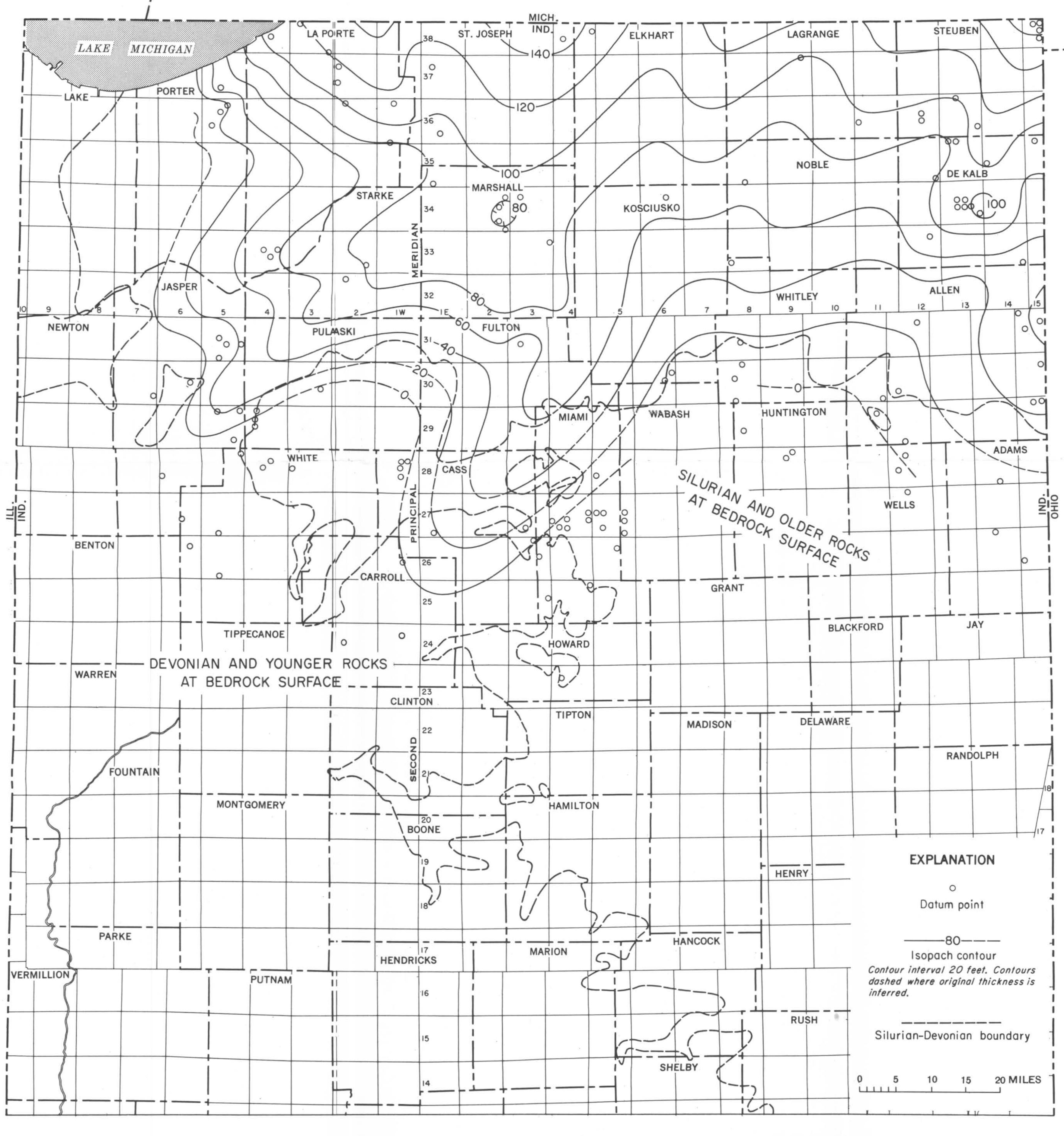


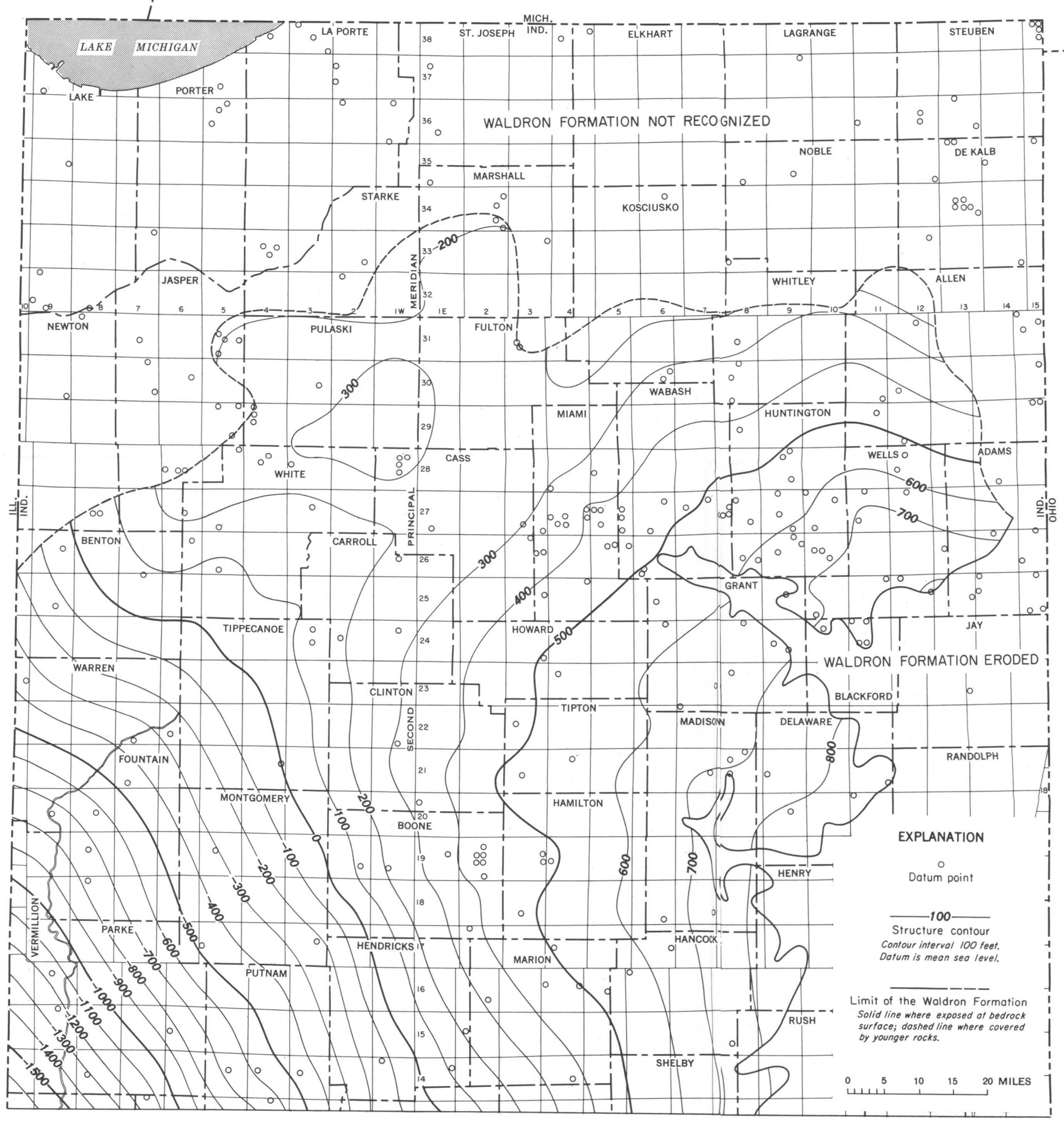
A. COMBINED THICKNESS OF THE BRASSFIELD LIMESTONE AND THE SALAMONIE DOLOMITE IN THE AREA OF THE OVERLYING WALDRON FORMATION



B. THICKNESS OF THE SALINA FORMATION. POST-DEVONIAN EROSION NOT CONSIDERED



C. THICKNESS OF ROCKS EQUIVALENT TO PART OF THE DETROIT RIVER GROUP OF MICHIGAN



D. STRUCTURE ON BASE OF THE WALDRON FORMATION

Base modified from U.S. Geological Survey Base map of Indiana, 1953.

Drafted by John E. Peace

MAPS SHOWING THICKNESS AND STRUCTURE OF SILURIAN ROCKS IN NORTHERN INDIANA

By Arthur P. Pinsak and Robert H. Shaver

1964